



Pawnee National Grassland Oil and Gas Leasing Analysis

**Final Environmental Impact Statement
December 2014**

**USDA Forest Service
Rocky Mountain Region
Arapaho and Roosevelt National Forests
and Pawnee National Grassland**

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Arapaho and Roosevelt National Forests and Pawnee National Grassland
Oil and Gas Leasing
Final Environmental Impact Statement
December 2014
Weld County, Colorado

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Abstract: This Final Environmental Impact Statement (FEIS) has been prepared to document and disclose the estimated environmental impacts of a decision to make available and apply lease stipulations to National Forest System lands within the Pawnee National Grassland. The FEIS analyzes the potential impacts of the Forest-wide land availability determination by using a Reasonable Foreseeable Development Scenario (RFD). The FEIS also proposes lease stipulations and identifies where those stipulations would be applied on future leases when needed on administratively available lands. The proposed action would make approximately 100,000 acres administratively available and close through management direction approximately 3,000 acres. Administratively available lands would include a No Surface Occupancy stipulation.

Three alternatives are analyzed in detail in the FEIS and include: Alternative 1: No Leasing; Alternative 2: No Action; and Alternative 3: Proposed Action.

Executive Summary

The Arapaho and Roosevelt National Forests and Pawnee National Grassland has prepared this Final Environmental Impact Statement (FEIS) to make a leasing decision for the Pawnee National Grassland (PNG). The following is provided as a summary of the major points in the FEIS.

In many parts of the United States, National Forest System lands overlie geological formations that may contain oil and/or natural gas. The US Forest Service's (Forest Service) national policy on minerals is expressed in the Minerals and Mining Policy Act of 1970 and states that the "[e]xploration, development, and production of mineral and energy resources and reclamation of activities are part of the Forest Service's ecosystem management responsibility." The Forest Service allows leases on many National Forest System lands for the purpose of drilling wells and extracting oil and/or gas. The Department of Interior, Bureau of Land Management (BLM), acts as the onshore leasing agent for the Federal Government. Forest Service regulations (36 CFR 228.102) developed in response to the Federal Onshore Oil and Gas Leasing Reform Act of 1987 (Leasing Reform Act) require a leasing analysis be completed prior to offering leases on National Forest System lands.

The leasing analysis involves two determinations. First, whether lands on the PNG will be administratively available for leasing. Second, what stipulations must be included in any leases issued that are not included in standard lease terms. Stipulations can include timing limitations, controlled surface use, and no surface occupancy.

Purpose and Need

The purpose of this FEIS is to complete a Grassland wide leasing analysis that complies with the Leasing Reform Act. There is a need for a leasing decision that:

1. Accounts for current environmental considerations and oil and gas demand;
2. Best meets Forest Plan direction; and
3. Fulfills the federal government's policy to "foster and encourage private enterprise in the development of economically sound and stable industries, and in the orderly and economic development of domestic resources to help assure satisfaction of industrial, security, and environmental needs" (Mining and Minerals Policy Act of 1970) while continuing to sustain the land's productivity for other uses and capability to support biodiversity goals (Forest Service Minerals Program Policy).

Stated briefly, the goal of this FEIS is to analyze different leasing alternatives on the PNG and determine which alternative best meets Forest Plan direction, Forest Service minerals policy, and the public interest.

Alternatives

Because the leasing analysis involves determinations on availability and stipulations, the alternatives analyzed in this FEIS have different combinations of lands available and stipulations. However, because the PNG contains a mixture of private mineral estate, existing leases, and unleased lands, these determinations will apply most directly to the unleased portion of the PNG (approximately 100,000 acres). There are two primary reasons for this. First, approximately 46,000 acres of the PNG lie above private mineral estate. Because the mineral estate is privately held, federal availability determinations and lease stipulations do not apply. Second, approximately 43,000 acres of the PNG are already leased. Because these lease rights are already granted, they will continue under their existing terms until they expire. However, if existing leases expire, the land availability and lease stipulation determinations under this decision will be included in any future leasing decisions on these lands.

The FEIS examines three alternatives in detail: (1) No Leasing; (2) No Action; and (3) No Surface Occupancy. Each of these alternatives is described briefly below:

Alternative 1-No Leasing

The No Leasing Alternative will designate all unleased lands on the PNG as administratively unavailable for lease. This means that no leases could be sold on these lands. Existing leases, if they expired, could also not be leased again.

Alternative 2-No Action

The No Action Alternative will continue the availability and stipulation determinations made as part of the 1997 Forest Plan. This decision made nearly all lands on the PNG available for leasing and included a mixture of stipulations (timing limitations, no surface occupancy, and controlled surface use). In short, these stipulations allow oil and gas development on the PNG surface so long as it conforms to the stipulations.

Alternative 3-No Surface Occupancy

The No Surface Occupancy Alternative will designate all unleased lands on the PNG as administratively available for lease. These lands will carry a no surface occupancy stipulation. This stipulation prohibits surface disturbance on the leasehold. In short, leases may be offered for sale, but once purchased, accessing and development of the oil and gas resource cannot occur directly on the surface of the leasehold and must be developed by off-site surface occupancy.

The No Surface Occupancy Alternative is the Forest Service's preferred alternative.

Potential Oil and Gas Activity on the PNG

While a leasing analysis determines if leases can be sold (and under what stipulations), it does not authorize oil and gas development. In order to develop a federal lease, an operator must file an Application for Permit to Drill (APD) with the BLM. This application includes a surface use and drilling plan and must be approved before any development is allowed. The APD is also subject to the NEPA process. Because the leasing analysis does not authorize any development, the Forest Service uses a projection of expected oil and gas development called a Reasonably Foreseeable Development Scenario (RFD).

BLM prepared an RFD for the Royal Gorge Field Office, which includes the PNG, in 2012. It projects oil and gas development over the next 20 years. In short, the RFD projects that, if the PNG is entirely available for lease under standard lease terms, that 265 new wells could be drilled in the short term. Of those wells, approximately 234 would remain in the long term.

Issues and Concerns

Issues and concerns were identified from interdisciplinary team analysis and comments received during the public involvement process. These issues and concerns are summarized below:

- Many respondents provided comments related to the impacts of hydraulic fracturing on groundwater, surface water, terrestrial wildlife, avian wildlife, soil, scenic, recreation, and air quality resources. They recommended that the EIS include disclosure of impacts to water rights, disposal of fluids, re-injection storage, the probability of leaks, the effects of leaks if they occur, and contamination avoidance measures were requested. Some comments included a recommendation that hydraulic fracturing be prohibited on the federal parcels of the project area. Other commenters recommended No Surface Occupancy (NSO) requirements on all remaining leasable lands on the Pawnee National Grassland.
- Several respondents provided comments related to the need for a thorough groundwater analysis that involves industry and science.
- A few respondents provided comments related to the benefits of horizontal or directional drilling with regard to minimizing environmental impacts. Some respondents also provided comments related to the limitations of directional drilling; the use of directional drilling must be determined on a case-by-case basis due to industry cost, control, and technical limitations.
- Some respondents provided comments related to soil degradation cause by increased road and pipeline construction to support the oil and gas operations.

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- Some respondents provided comments related to potential effects to wildlife species due to increased oil and gas operations and activity. The species listed included terrestrial, avian, and particularly sensitive and threatened species, either federally or state listed. These include: black-tailed prairie dogs, burrowing owls, swift fox, mountain plover, ferruginous hawk, long-billed curlew, Brewer's sparrow, McCowan's longspur, chestnut-collared longspur, grasshopper sparrow, and Brewer's sparrow. The potential effects could be caused by the development of roads and pipelines which can cause habitat fragmentation or degradation, edge effects, and direct mortality.
 - Some comments recommended stipulations in the Environmental Impact Statement (EIS) for: no oil and gas development adjacent to or in prairie dog towns; wild-to-wild relocation, which entails relocating prairie dogs from disturbed burrows to vacant burrows in alternate locations; reverse dispersal translocation (RDT), which entails coaxing prairie dogs out of an area and gradually closing down vacant burrows; and restricting vehicles from within active prairie dog colonies.
 - A few respondents provided comments related to negative effects on recreational activities due to increased oil and gas operations and activity. The potential reductions in bird species and populations, as well as visual obstructions caused by oil and gas equipment were cited as potential causes for a reduction in bird watching activity on the Grassland.

Environmental Consequences

Forecasting environmental impacts for a leasing analysis is problematic because it is not known precisely where or what development will be proposed. In addition, Conditions of Approval and other specific mitigation are not determinable until an APD is submitted. These details are critical to evaluating the environmental impacts of oil and gas development. However, given the RFD's projection, it is possible to draw some broad generalizations about environmental effects of making lands available for leasing and how well leasing stipulations address environmental concerns.

Oil and gas development is an industrial operation and involves surface disturbance. As a result, some environmental impacts or risk are inevitable. These can include impacts to water resources, terrestrial and aquatic species, scenery, recreation, air quality, and traffic. While the specific impacts of development are hard to determine at the leasing analysis stage, in general, the more wells, well pads, roads, and other oil and gas development on the PNG, the greater the risk of environmental impact.

The primary environmental impacts of the alternatives include the following:

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- No Leasing will likely result in the greatest risk of environmental impacts. This is because of production inefficiency to avoid the federal mineral estate which is intermixed with private and state minerals. It is estimated that approximately 10% more wells, well pads, and surface disturbance would be needed under this alternative due to spacing constraints and access. All wells, well pads, and surface disturbance would occur outside the PNG; however, not leasing these lands would likely involve more impacts than leasing.
 - No Action will likely have the second greatest risk of environmental impacts. This is because it would generally allow for surface occupancy of the PNG to extract federal minerals. While the stipulations identified in the 1997 Forest Plan would provide some protection for resources, there are some resources that will be subject to environmental risk. There are no stipulations associated with sensitive aquifers, few stipulations for scenery, no stipulation for recreation resources or for aquatic species, and the benefit of some of the wildlife stipulations may not be adequate.
 - No Surface Occupancy is expected to have the least risk of environmental impacts. This is because there will be no wells, well pads, or surface disturbance on the PNG and development would occur more efficiently between federal and non-federal minerals. It is likely that oil and gas development will be located on lands adjacent to the PNG. However, because the PNG would be available for lease, the potential development is expected to occur more efficiently and with less total surface impacts under the No Surface Occupancy alternative due to advances in horizontal drilling technology. Under this alternative all resources on the PNG would be exposed to the least risk of environmental impacts because these developments would simply not occur on the PNG and the indirect effects from private development would be reduced.

Oil and gas technology has also changed in recent years. Most importantly, horizontal drilling has become the dominant method of extraction. This method increases the subsurface space that is accessible by one well bore, reducing the number of wells needed to develop a lease. In addition, horizontal wells can extend up to 1.5 miles underground allowing for a greater distance between the well pad and the minerals. Horizontal drilling is an important factor for the leasing decision because all the federal minerals can be accessed by drilling from off-site locations with horizontal wells. Therefore, 100% of the federal minerals can be developed without surface occupancy of the PNG. Stated another way, so long as lands on the PNG are available for lease, all of the federal minerals can be developed no matter what stipulations are placed on those leases. For this reason, there is no difference in recoverability between the No Action Alternative and the No Surface Occupancy Alternative.

TABLE OF CONTENTS

TABLE OF CONTENTS.....	TOC 1
LIST OF FIGURES	TOC 2
LIST OF TABLES	TOC 4
Pawnee Oil and Gas EIS Chapter 1	1
Introduction.....	1
1.1. Background on Oil and Gas Leasing on NFS lands.....	1
1.2. Federal Process	2
1.3. Leasing Analysis and Decision	3
1.4. Oil and Gas Leasing on the Pawnee National Grassland.	8
1.5. Purpose and Need for Action	8
1.6. Scope of this Analysis.....	9
1.7. Reasonably Foreseeable Development (RFD)	10
1.8. Decisions to be Made.....	14
1.9. Lands affected by this decision	15
1.11. Issues.....	17
1.12. Issues Dismissed from Detailed Study	18
Pawnee Oil and Gas EIS Chapter 2	19
Introduction	19
2. Alternatives Considered in Detail.....	19
2.1. No Leasing Alternative	20
2.2. No Action Alternative.....	23
2.3. No Surface Occupancy Alternative.....	26
2.4. Summary Comparison of Alternatives.....	29
2.5. Forest Service Preferred Alternative.....	30
2.6. Alternatives Considered but Dismissed from Detailed Study.....	30
2.7. Summary of Environmental Impacts by Alternative.....	33
Pawnee Oil and Gas EIS Chapter 3	35
Introduction	35
3.1 Oil and Gas Development	35
3.2 General Environmental Concerns or Impacts of Oil and Gas Development and Hydraulic Fracturing	38
3.3 Why No Leasing results in more surface disturbance, wells, and well pads.	41
3.4 Incomplete and Unavailable Information.....	48
3.5 Assumptions.....	49
3.6 Affected Environment and Environmental Consequences.....	50
3.7 Hydrology and Soils Resources	50
3.8 Fisheries Resources.....	87
3.9 Wildlife Species and Habitats	115
3.10 Air Quality	132
3.11 Geology/Minerals.....	191
3.12 Recreation	206
3.13 Scenery.....	231
3.14 Heritage.....	242
3.15 Transportation.....	255
3.16 Economics.....	264

Chapter 4-Response to Comments	313
Chapter 5-List of Preparers and Persons, Agencies, and Organizations Who Received a Copy of the FEIS	339
5.1 List of Preparers:	339
5.2 Distribution of FEIS	340
References	341
Appendix A	
Appendix B	
Appendix C	

LIST OF FIGURES

Figure 1—Royal Gorge Field Office	10
Figure 2 Land and Mineral Estate.....	16
Figure 3 No Leasing Alternative.....	22
Figure 4 No Action Alternative	25
Figure 5 No Surface Occupancy Alternative	28
Figure 6 Example of Well Pad Construction	36
Figure 7 Example of Drilling	37
Figure 8 Example of Hydraulic Fracturing	37
Figure 9 Example Producing Well with Interim Reclamation Completed	38
Figure 10 Well and pad analysis for the No Leasing Alternative in T. 9 N. R. 58 W.	43
Figure 11 Well and pad analysis for the NSO alternative in T. 9 N. R. 58 W.	43
Figure 12 Well and pad analysis for the No Leasing alternative in T. 9 N. R. 58 W.	44
Figure 13 Well and pad analysis for the NSO alternative in T. 9 N. R. 63 W.	45
Figure 14 Well and pad analysis for the No Leasing alternative in T. 9 N. R. 64 W.	46
Figure 15 Well and pad analysis for the NSO alternative in T. 9 N. R. 64 W.	46
Figure 16 Well and pad analysis for the No Leasing alternative in T. 9 N. R. 65 W.	47
Figure 17 Well and pad analysis for the NSO alternative in T. 9 N. R. 65 W.	48
Figure 18 HUC6 watersheds representing 60% of FS lands on the PNG	53
Figure 19 Streams, lakes, and other water sources on the PNG	56
Figure 20 Highly erosive areas, mapped wetland, riparian and pothole areas on the PNG	58
Figure 21 Watershed Improvement Need Inventory sites on the PNG.....	60
Figure 22 Hydrogeological Settings on the PNG.....	62
Figure 23 DRASTIC parameter tables	67
Figure 24 DRASTIC model results: Areas of the PNG with high groundwater vulnerability	70
Figure 25 Water level changes in perennial surface water habitats from July 2012 to October 2013 in the South Pawnee Creek drainage, Pawnee National Grassland, Weld County, Colorado. Water levels above dashed lines approximate periods when surface flow were present.	88
Figure 26 Maps of the East and West units of the Pawnee National Grassland depicted to distribution of movement corridors, suitable aquatic habitat, and occupied aquatic habitat, Weld Cty, Colorado....	91
Figure 27 Quantity of produced water (blue line) and number of spills (red line) reported to Colorado Oil and Gas Conservation Commission for Weld County Colorado from 2004 to 2013. Source: Colorado Oil and Gas Conservation Commission Online Database.....	104
Figure 28 Project Area and Designated Air Boundary Intersections	137
Figure 29 Ozone Nonattainment Area	143
Figure 30 Land Ownership and the Ozone Nonattainment Area on the Pawnee National Grassland	144

Figure 31 Design Values in Areas Previously Designated Nonattainment for the 8-Hour Ozone NAAQS	144
Figure 32 Daily Maximum 8-hour Ozone Concentrations at Pawnee NG Monitors	145
Figure 33 Trend in haze index (deciview) on the 20% clearest and haziest days at Rocky Mountain National Park.	147
Figure 34 Annual trends in nitrate (NO ₃) concentrations in wet deposition collected by the Pawnee (CO 22) National Atmospheric Deposition Program monitor.	148
Figure 35 Annual trends in sulfate (SO ₄) concentrations in wet deposition collected by the Pawnee (CO 22) National Atmospheric Deposition Program monitor.	149
Figure 36 Annual trends in wet nitrogen deposition collected by the Pawnee (CO 22) National Atmospheric Deposition Program monitor.	149
Figure 37 Air Quality Analysis Area	153
Figure 38 CARMMS Modeling Domain	157
Figure 39 Maximum Modeled Contributions to 1 Hour Daily Maximum NO ₂ Concentrations from PNG 2021 Development Scenario.	159
Figure 40 Maximum Modeled Contributions to Annual Average NO ₂ Concentrations from PNG 2021 Development Scenario.	160
Figure 41 Maximum Modeled Contributions to 1 Hour Daily Maximum SO ₂ Concentrations from PNG 2021 Development Scenario	161
Figure 42 Maximum Modeled Contributions to Annual Average SO ₂ Concentrations from PNG 2021 Development Scenario	162
Figure 43 Maximum Modeled Contributions to Ozone Concentrations from PNG 2021 Development Scenario.....	163
Figure 44 Fourth Highest Daily Maximum 8-hour Ozone Concentrations for the 2008 Base Case (left) and the 2021 High Development Scenario (right)	167
Figure 45 Baseline and Predicted Future Design Values for Ozone (ppb) Results from the Modeled Attainment Test Software Relative Analysis	168
Figure 46 Eighth highest 24-hour PM _{2.5} Concentrations for the 2008 Base Case (left) and the 2021 High Development Scenario (right).....	172
Figure 47 Annual Average PM _{2.5} Concentrations for the 2008 Base Case (left) and the 2021 High Development Scenario (right).....	173
Figure 48 Second Highest 24-hour Average PM ₁₀ Concentrations for the 2008 Base Case (top left) and 2021 High Development Scenario.	174
Figure 49 Contribution of PNG Oil and Gas Sources to 2nd-Highest 24-hour PM ₁₀	174
Figure 50 Modeled change in the 2nd highest daily average PM ₁₀ concentration from 2008 to 2021...	175
Figure 51 Fourth highest (98th percentile) daily maximum 1-hour average SO ₂ concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right).....	176
Figure 52 . Second highest 3-hour average SO ₂ concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right).....	176
Figure 53 . Annual average SO ₂ concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right).....	177
Figure 54 Modeled change in the 4th highest 1-hour daily maximum (left) and annual (right) SO ₂ concentrations from 2008 to 2021	178
Figure 55 Eighth highest daily maximum 1-hour average NO ₂ concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right)	179
Figure 56 Average Annual NO ₂ Concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right).....	179
Figure 57 Modeled change in the 8th highest 1-hour daily maximum (left) and annual NO ₂ concentrations (right) from 2008 to 2021	180
Figure 58 Second Highest Daily Maximum 1-hour Average CO Concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right)	181

Figure 59 Second Highest 8-hour Average CO Concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right)	182
Figure 60 Modeled change in the 2nd highest 1-hour daily maximum (left) and 2nd highest 8-hour CO concentrations (right) from 2008 to 2021	183
Figure 61 Example of Parcel Development with and without Federal Minerals	204
Figure 62 Recreation Components on the PNG	208
Figure 63 Unemployment 1990-2011	272
Figure 64 Industry Employment	274
Figure 65 Per Capita Income	276
Figure 66 Violent Crime 1992-2011	283
Figure 67 Juvenile Crime 1992-2011	284
Figure 68 Distribution of State Severance Tax Receipts	294
Figure 69 Distribution of Federal Mineral Lease Revenue in Colorado	296

LIST OF TABLES

Table 1—Short Term RFD Well Projection.	11
Table 2—Long Term RFD Well Projection	11
Table 3—Short Term RFD Disturbed Sites Projection.....	12
Table 4—Long Term RFD Disturbed Sites Projection.....	12
Table 5 RFD Short Term Surface Disturbance Projection (acres).....	12
Table 6—RFD Long Term Surface Disturbance Projection	13
Table 7 Summary of Acres of Available for Development under No Leasing Alternative	20
Table 8 Summary of Acres Available for Development under the No Action Alternative	23
Table 9 Existing Forest Plan Stipulations	23
Table 10 Summary of Acres Available for Development under the No Surface Occupancy Alternative ..	26
Table 11 Summary of Stipulations on Federal Mineral Leases under the No Surface Occupancy Alternative.....	26
Table 12 Land Available for Leasing and Stipulations for Unleased Portion of PNG	29
Table 13 Total PNG Acres Available for Leasing and Applicable Stipulations	29
Table 14 Summary Comparison Table	33
Table 15. Summary of the theoretical impacts from the No Leasing and NSO alternatives in T. 9 N. R. 58 W.....	44
Table 16. Summary of the theoretical impacts from the No Leasing and NSO alternatives in T. 9 N. R. 63 W.....	45
Table 17. Summary of the theoretical impacts from the No Leasing and NSO alternatives in T. 9 N. R. 64 W.....	47
Table 18. Summary of the theoretical impacts from the No Leasing and NSO alternatives in T. 9 N. R. 65 W.....	48
Table 19 HUC6 watersheds representing 60% of FS lands on the PNG	51
Table 20 Hydrogeological settings and Geology of the PNG	61
Table 21 Acres open to surface disturbance by alternative and HUC6 watershed (Forest Service land)...	73
Table 22 Acres of potential disturbance or protection to vulnerable groundwater resources	79
Table 23 Acres with high sediment contribution potential disturbed or protected, by alternative	81
Table 24 Acres of potential soil productivity changes due to surface disturbance or protection, by alternative.....	81
Table 25 Acres of mapped wetland, riparian and potholes disturbance and protection per alternative	83
Table 26 Summary of effects	86
Table 27 . Summary of the amount and distribution of aquatic habitat	89

Table 28 The list of aquatic species for which environmental impacts have been examined in the Final Environmental Impact Statement. Includes special status and reason for in depth analysis. Note: Pallid sturgeon is included as federally-listed species of Platte.....	93
Table 29 Consequences of water depletions compared among alternatives.	99
Table 30 Consequences of habitat sedimentation to 33 miles of suitable aquatic habitats on the Pawnee National Grassland compared among alternatives.	102
Table 31 Concentration of oil & gas related constituents (mg/L) in surface water, ground water, and produced water within 0.25 mile of PNG lands, Weld Co.....	105
Table 32 Consequences of habitat contamination compared among alternatives.....	107
Table 33 Distribution of potential fragmentation sites along streams on the Pawnee National Grassland, Weld Co., Colorado.	108
Table 34 Consequences of habitat fragmentation compared among alternatives.	110
Table 35 Summary of the distribution, extent, and current status of fish occurrence in occupied aquatic habitats on the PNG, Weld Co, Colorado.	112
Table 36 Threatened and Endangered Species Considered in this Analysis.....	116
Table 37 Sensitive Species Considered in this Analysis.....	117
Table 38 Potential Acres by Species in Wildlife Analysis Area.....	119
Table 39 Acres of Land Disturbance during Construction and Reclamation Stage and Road Miles Based on 960 acres of well pads and 30 miles of Road.....	120
Table 40 Terrestrial Key Indicators and Evaluation Measures	121
Table 41 Total Road Density within the PNG Administrative Boundary by Alternative.....	127
Table 42 Comparison of Indicators by Alternative.....	128
Table 43 Summary of Impact Determinations To Sensitive Wildlife Species	130
Table 44 Summary of Determinations for MIS species.....	131
Table 45 National Ambient Air Quality Standards.....	133
Table 46 2011 Emissions by County (tons).....	138
Table 47 Maximum Measured Criteria Pollutant Concentrations for Select Counties in Northeastern Colorado: 2011 to 2013.....	140
Table 48 Estimated Emissions from Additional Oil and Gas Development under the 2021 Development Scenario.....	156
Table 49 Highest PSD Pollutant Concentrations at any Class I or II Area due to Emissions from PNG Area Oil and Gas Development (units are $\mu\text{g}/\text{m}^3$).....	159
Table 50 Maximum Pawnee NG Impacts to Visibility (dv)	164
Table 51 Highest Maximum and Average Nitrogen Deposition Impacts Under 2021 Scenario (kg/ha/yr.) from Pawnee NG Oil and Gas Development	165
Table 52 Highest Maximum and Average Sulfur Deposition Impacts Under 2021 Scenario (kg/ha/yr.) from Pawnee NG Oil and Gas Development	165
Table 53 Projected Changes in Acid Neutralizing Capacity at Sensitive Lakes Due to Federal Oil and Gas Development Within the Pawnee NG Planning Area.	166
Table 54 Projected Cumulative Impacts to Visibility in Class I Areas.....	169
Table 55 Cumulative Deposition at Class I Areas for 2021 High Development Scenario	170
Table 56 Cumulative Deposition at Class II Areas for 2021 High Development Scenario	171
Table 57 Maximum Annual Potential Greenhouse Gas Emissions from Pawnee NG Development Under the 2021 High Development Scenario (tons).....	188
Table 58 Management Areas on the PNG	235
Table 59 Scenic Integrity Objective Acreage Summary for Alternative 1	241
Table 60 Scenic Integrity Objective Acreage Summary for Alternative 2	241
Table 61 Scenic Integrity Objective Acreage Summary for Alternative 3	241
Table 62 Scenic Integrity Objective Compliance by Alternative	242
Table 63. Prehistoric Cultural Resource Types on the PNG.....	243
Table 64. Historic Cultural Resource Types on the PNG	243

Table 65. Cultural Components within the Prehistoric Chronology for the Platte River Basin	243
Table 66: Summary of Potential Impacts to Previously Recorded Cultural Resources by Alternative	254
Table 67 Miles of Forest Service Roads on the Pawnee National Grasslands.....	255
Table 68 Miles of road that are non-Forest Service jurisdiction or non-NFSR roads on the Pawnee National Grasslands**	256
Table 69 Management Area Summary	259
Table 70 Estimates of traffic from oil and gas development and production.	262
Table 71 Population Totals: Current and Historic	266
Table 72 Population Projections 2015-2030.....	266
Table 73 Components of Population Change between 1980 and 2010.....	267
Table 74 People per Square Mile.....	268
Table 75 Gender Distribution: Percent of Total Population	269
Table 76 Racial and Ethnic Composition	270
Table 77 Educational Attainment, Percent of Persons Age 25+	271
Table 78 Non-Labor Income as a Percent of Total Personal Income, 2010	277
Table 79 Poverty Rates, 2011	278
Table 80 Housing Availability, 2011	279
Table 81 Housing Costs, 2011	280
Table 82 Detailed Poverty Rates, 2011.....	282
Table 83 January 1st Cattle and Calve Inventories, 2003-2013.....	288
Table 84 Anticipated Public Revenues Generated Under Alternative 1	305
Table 85 Anticipated Public Revenues Generated Under Alternative 2.....	305
Table 86 Anticipated Public Revenues Generated Under Alternative 3.....	312

Pawnee Oil and Gas EIS Chapter 1

Introduction

The Arapaho and Roosevelt National Forests and Pawnee National Grassland together with the Bureau of Land Management (as a cooperating agency) has prepared this Final Environmental Impact Statement (FEIS) to evaluate oil and gas leasing on the Pawnee National Grassland (PNG). This FEIS was prepared in order to inform a leasing analysis decision. This decision determines what lands on the PNG would be available for oil and gas leasing and what lease stipulations would be attached to any future leases. This FEIS discloses and discusses the potential environmental impacts of oil and gas leasing across a range of alternatives in order to make this decision.

To provide the reader with a foundation for this analysis, this Chapter includes:

- (1) A background on oil and gas leasing on National Forest System lands;
- (2) A discussion of the federal process for oil and gas leasing and oil and gas development on National Forest System Lands;
- (3) Oil and gas leasing on the PNG
- (4) A discussion of the purpose and need for action;
- (5) A discussion on the scope of the analysis;
- (6) A description of the projections of future oil and gas development under the reasonably foreseeable development scenario (RFD)
- (7) A statement of the decisions to be made;
- (8) A description of the lands involved;
- (9) A discussion of public participation and significant issues;
- (10) Issue considered in detail in this analysis;
- (11) Issues dismissed from detailed study

1.1. Background on Oil and Gas Leasing on NFS lands

In many parts of the United States, National Forest System (NFS) lands overlie oil and gas resources. The Forest Service manages NFS lands, outside of statutory wilderness areas and other limited use designations, for a spectrum of uses under the Multiple-Use Sustained Yield Act of 1960. Part of the Forest Service's multiple use mission is to allow for the exploration, development, and production of oil and gas resources while sustaining the long term health and biological diversity of ecosystems.¹

¹ See Forest Service Manual (FSM) 2822.03 which describes the FS's policy on mineral leasing.

To fulfill this mission, the Forest Service (FS) and Bureau of Land Management (BLM) work together to lease oil and gas on NFS lands.² The Federal Onshore Oil and Gas Leasing Reform Act of 1987 divides the responsibility for issuing oil and gas on NFS lands between the Secretary of Interior, acting through the BLM, and the Secretary of Agriculture, acting through the Forest Service.

As of February 2012, the Forest Service estimates that, nationwide, approximately 5 million acres of NFS lands are currently leased for oil, gas, coal, and phosphate mining. Federal procedures establish a process the Forest Service and BLM follow in order to make decisions regarding the leasing of NFS lands.

1.2.Federal Process

The Code of Federal Regulations (CFR) sets forth the process the FS and BLM follow to make decisions regarding the exploration, development, and production of oil and gas resources on NFS lands.³ In short, these regulations establish a staged decision making process. There are two stages: (1) leasing of federal oil and gas; and (2) development of the lease.

The staged decision making process is illustrated by the distinct decisions the FS and BLM must make. There are four National Environmental Policy Act (NEPA) based decisions the FS and BLM make in deciding whether oil and gas development can occur on NFS lands. These decisions and a short description are:

- (1) FS leasing analysis and decision—what lands are available for leasing and what stipulations are necessary.⁴
- (2) BLM lease sale decision—whether to sell a lease on available lands and what stipulations are necessary.⁵
- (3) FS review of leaseholder’s SUPO—whether the plan is consistent with the lease and acceptable (or can be made acceptable) based on environmental considerations.⁶
- (4) BLM decision on leaseholder APD —whether “on the ground” activities will be authorized.⁷

Because these are NEPA based decisions, they all require the consideration of environmental consequences and opportunities for public involvement.

² FSM 2022.04 describes the FS and BLM’s responsibilities with respect to leasable minerals. In addition, the FS and BLM have signed a Memorandum of Understanding (MOU) for the purpose of establishing joint BLM and FS policies and procedures for managing oil and gas leasing and operational activities pursuant to oil and gas leases on NFS lands. http://www.fs.fed.us/geology/MOU_BLM_Oil_Gas.pdf

³ 36 CFR Subpart E describes Forest Service and 43 CFR Part 3100 describes BLM rules and procedures for oil and gas leasing.

⁴ 36 CFR 228.102

⁵ 43 CFR Subpart 3101

⁶ 36 CFR 228.106 through 36 CFR 228.109

⁷ 43 CFR § 3162.3–1.

The FS and BLM are currently in the first stage and the focus of this EIS is to complete a leasing analysis and decision.

1.3. Leasing Analysis and Decision

The FS uses the leasing analysis to make two determinations—a land availability determination and a lease stipulation determination. First, the FS determines what NFS lands will be available for leasing (land availability determination). Second, if the FS determines that lands are available for leasing, the FS next decides what stipulations will be required in the lease (lease stipulation determination).

The FS completes the leasing analysis under NEPA procedures to ensure that environmental impacts are considered in decision making. In evaluating the environmental impacts, the Forest Service projects the type/amount of post-leasing activity that is reasonably foreseeable as a consequence of conducting a leasing program consistent with that described in the proposal and for each alternative. This projection is called a Reasonably Foreseeable Development Scenario (RFD)⁸ and is an estimate of oil and gas development in the analysis area for a specified period of time (usually between 10 and 20 years).

The FS uses this projection to analyze the reasonable foreseeable impacts of post-leasing activity.⁹ As a result, this projection provides the basis for the evaluation of the environmental impacts under NEPA.

1.3.1.1. Land Availability Determination

In substance, a land availability determination defines whether oil and gas leasing is allowed whatsoever on NFS lands. For the land availability determination, the Forest Service places NFS lands on the PNG into one of three categories. These categories are:

- (1) Lands closed to leasing by law or regulation;
- (2) Lands available for leasing through management discretion; and
- (3) Lands closed to leasing through management discretion.

The land availability determination first identifies lands that are closed to leasing by law or regulation (e.g. Wilderness Areas of Withdrawn Areas). These lands are legally unavailable for leasing and are excluded from further review in the land availability determination.

For remaining lands, the Forest Service identifies what lands will be open or closed to leasing through management discretion.

⁸ See BLM Handbook 1624-1 and BLM Instructional Memorandum (IM) 2004-89. An RFD is “a reasonable, technical, and scientific estimate of anticipated oil and gas activity based on current information and data available.”

⁹ 36 CFR 228.102(c).

1.3.1.2. Lease Stipulation Determination

The lease stipulation determination only applies to lands the Forest Service has defined as available through management discretion. For these lands, the Forest Service determines what stipulations must be included on any future leases.

Lease stipulations are additional restrictions or constraints placed on a lease and become part of the lease issued by BLM. The purpose of lease stipulations is to reduce potential adverse impacts of operations on NFS surface resources or to implement forest plan management direction.¹⁰

Lease stipulations fall into one of three categories:¹¹

- (1) No Surface Occupancy (NSO)
- (2) Timing Limitations (TL)
- (3) Controlled Surface Use (CSU)

Standard Lease Terms (SLTs) are included on every lease issued by BLM. If SLTs are not determined to be adequate to protect surface resources, additional stipulations are developed.¹² These include no surface occupancy (NSO), timing limitations (TL), and controlled surface use stipulations (CSU). When additional stipulations are required, they supersede any inconsistent provisions in SLTs.

Stipulations are described briefly here and in detail in Appendix A.

Standard Lease Terms

Standard Lease Terms (SLTs) are contained in BLM Form 3100-11—Offer to Lease and Lease for Oil and Gas, U.S. Department of the Interior, BLM, October 1992. Form 3100-11 is standard nationwide and is applied to every lease issued.

Under SLTs, the right to use of the leased lands is subject to reasonable measures needed to minimize adverse impacts. 43 CFR 3101.1-2 defines what reasonable measures can be required. These include:

- (1) relocation of proposed operations up to 200 meters;

¹⁰ See 53 FR 10423-01 which states that: "Appropriate stipulations would be those necessary to implement the management direction in the forest plan as well as those identified in the environmental document(s) as mitigation measures for possible adverse impacts of oil and gas operations on National Forest System surface resources."

¹¹ See "Uniform Format for Oil and Gas Leasing Stipulations"; Final Recommendations Prepared By: Rocky Mountain Regional Coordinating Committee March 1989. Available at: <http://www.blm.gov/pgdata/etc/medialib/blm/wy/programs/energy/og/leasing/saleforms.Par.4059.File.dat/uniformformat-stips.pdf>

¹² FSM2822.42 provides some guidance on determining the need for stipulations. It states that they should be "...necessary to protect the use, management, administration, and development of the National Forest System lands and the Forest Development Road Systems. Stipulations should be held to a minimum consistent with those purposes."

(2) prohibit new surface disturbing operations for a period up to 60 days in any lease year

No Surface Occupancy

No Surface Occupancy (NSO) lease stipulations prohibit any surface disturbing activities on the leasehold. This means that wells and well pads cannot be located on leaseholds. However, the NSO stipulation does not prohibit the FS from evaluating special use permit applications for roads, pipelines, or other uses. Any applications for these uses are evaluated under Forest Service special uses regulations.¹³

NSO stipulations can apply to the entire lease, as a specified distance from resources and facilities; such as rivers, trails, campgrounds, etc., or other geographic features. The NSO stipulation is generally used when all other stipulations do not sufficiently protect surface resources.

Timing Limitations

Timing Limitation (TL) lease stipulations prohibit surface use during specified time periods. Because SLTs provide the authority to prohibit surface use for up to 60 days, timing limitation stipulations are generally used when necessary to protect resource values that require prohibiting surface use in excess of 60 days.

Controlled Surface Use

Controlled Surface Use (CSU) lease stipulations are intended to be used when surface use is generally allowed on all or portions of the lease area year round, but because of special values or resource concerns, lease activities must be strictly controlled. CSU lease stipulations may be required for certain resources that require special design, construction, operation, mitigation, implementation, reclamation, and monitoring measures, including relocation of operations by more than 200 meters.

1.3.2. After the Leasing Analysis and Decision

The FS completes the leasing analysis by issuing a Record of Decision (ROD) and notifying BLM by providing them a copy of the leasing analysis. The BLM will determine whether to adopt the Oil and Gas Leasing EIS and associated analysis. In that decision, the BLM will conduct an independent review and determine if the EIS adequately addresses all likely significant environmental impacts associated with the BLM's responsibilities for oil and gas leasing and development on the PNG, as well as if all BLM requirements and comments were adequately addressed by the Forest Service. The BLM may identify specific tracts of NFS lands be leased. If NFS tracts are identified, the FS will determine whether to consent with BLM to

¹³ The procedures for evaluating special use applications are listed in 36 CFR 251 Subpart B.

offer the lease.¹⁴ If the FS consents to BLM’s decision to offer the lease, BLM may lease minerals underlying NFS lands—typically through a competitive lease sale.

If a lease is issued on NFS lands, the leaseholder may submit an APD. The submission of the APD triggers review and evaluation by the Forest Service and BLM in order for any development of the oil and gas lease.

1.3.3. Development of Federal Oil and Gas Leases on NFS Lands

Prior to any development of an oil and gas lease on NFS lands, the leaseholder must submit an APD for review and consent by the BLM and Forest Service. In general, an APD is a plan for drilling and surface use on the leasehold.¹⁵ The APD includes, among other requirements, a drilling plan and a Surface Use Plan of Operations (SUPO). The drilling plan includes a description of the drilling program, the surface and projected completion zone location, pertinent geologic data, expected hazards, and proposed mitigation measures to address such hazards. The SUPO includes the road and drillpad location, details of pad construction, methods for containment and disposal of waste material, plans for reclamation of the surface, and other pertinent data.

Similar to leasing, the BLM and FS share the authority over the review and approval of APDs¹⁶. The FS is responsible for review of the SUPO and the BLM is responsible for overall review and approval or disapproval of the APD. This review is consistent with FS responsibilities for surface resources and BLM responsibilities for subsurface or “downhole” issues—such as drilling and casing.

¹⁴ The procedures for Forest Service authorization to BLM is described at 36 CFR 228.102. It states that:
At such time as specific lands are being considered for leasing, the Regional Forester shall review the area or Forest-wide leasing decision and shall authorize the Bureau of Land Management to offer specific lands for lease subject to:

- (1) Verifying that oil and gas leasing of the specific lands has been adequately addressed in a NEPA document, and is consistent with the Forest land and resource management plan. If NEPA has not been adequately addressed, or if there is significant new information or circumstances as defined by 40 CFR 1502.9 requiring further environmental analysis, additional environment analysis shall be done before a leasing decision for specific lands will be made. If there is inconsistency with the Forest land and resource management plan, no authorization for leasing shall be given unless the plan is amended or revised.
- (2) Ensuring that conditions of surface occupancy identified in § 228.102(c)(1) are properly included as stipulations in resulting leases.
- (3) Determining that operations and development could be allowed somewhere on each proposed lease, except where stipulations will prohibit all surface occupancy.

¹⁵ 43 CFR 3162.3-1 describes the information to be included in the APD.

¹⁶ Onshore Oil and Gas Order Number 1

The SUPO and APD are subject to site specific review under NEPA. The Forest Service reviews and makes a NEPA based decision on the SUPO. If the SUPO is approved, the BLM then reviews and makes a NEPA based decision the APD.

36 CFR 228.107(a) lists four determinations the Forest Service must make to approve a SUPO. These determinations are:

- (1) That the SUPO is consistent with the lease, including the lease stipulations, and applicable Federal laws.
- (2) That the SUPO is consistent or can be made consistent with the Forest Plan.
- (3) That the SUPO meets or exceeds the surface use requirements in 36 CFR 228.108.¹⁷
- (4) That the SUPO is acceptable, or is modified to be acceptable, based upon a review of the environmental consequences of the operations.

The BLM review of the APD includes technical considerations related to “downhole” operations and any environmental considerations identified in the NEPA analysis of the APD.¹⁸ After environmental analysis, BLM issues a NEPA based decision on the APD.

The Forest Service and BLM may require Conditions of Approval to mitigate site specific resource concerns. Only after the APD and associated SUPO are approved may the applicant proceed with drilling the well after the APD is signed by the BLM authorizing official. All activity must conform to the APD, SUPO, and lease stipulations.

1.3.4. Modifications, Waivers, and Exceptions

An operator may request the FS authorize BLM to modify (permanently change), waive (permanently remove), or grant an exception (case-by-case exemption) to a stipulation included in a lease at the direction of the Forest Service.¹⁹ The Forest Service reviews requests for modifications, exceptions, and waivers under the NEPA process. In order to authorize BLM to grant a modification, waiver, or exception; the Forest Service must make four determinations:

- (1) The action would be consistent with applicable Federal laws;
- (2) The action would be consistent with the current forest land and resource management plan;
- (3) The management objectives which led the Forest Service to require the inclusion of the stipulation in the lease can be met without restricting operations in the manner provided

¹⁷ 36 CFR 228.108 lists ten surface use requirements. These requirements include; among others, that operations are conducted in a manner that minimizes effects on surface resources and prevents unnecessary or unreasonable surface resource disturbance. They also require the operator conduct reclamation and that operations protect watersheds.

¹⁸ BLM Handbook 3160-1 identifies the guidelines and procedures for processing APDs, oil and gas tests, and subsequent operations under an onshore Federal or Indian oil and gas lease.

¹⁹ See 36 CFR 228.104 for a description of the FS process for the consideration of modifications, waivers, and exceptions.

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- for by the stipulation given the change in the present condition of the surface resources involved, or given the nature, location, timing, or design of the proposed operations; and
- (4) The action is acceptable to the authorized Forest officer based upon a review of the environmental consequences.

1.4.Oil and Gas Leasing on the Pawnee National Grassland.

Oil and Gas leasing has been occurring on the PNG since the 1930s. The most recent leasing analysis was completed in 1997 as part of a Forest Plan revision. The 1997 leasing analysis relied on a reasonably foreseeable development scenario (RFD) developed in 1995. Since 1997, oil and gas leasing has been occurring under the availability and stipulation determinations defined in that analysis. Currently, approximately 43,000 acres of the PNG are leased and 62 oil and gas wells are active.

Since 1997, interest in oil and gas resources on the PNG has increased and the technology to extract oil and gas has changed. One of the important technological changes is the way oil and gas is extracted—changing from conventional to horizontal drilling. As a result, BLM developed a new reasonably foreseeable development scenario (RFD) in 2013. The 2013 RFD projects that 234 new wells will be developed in the long term on the PNG over the next 20 years.

1.5.Purpose and Need for Action

1.5.1. Need for Action

Conditions have changed since the 1997 Forest Service’s leasing decision. First, a new RFD was prepared in 2013. Second, interest in oil and gas resources under the PNG has increased since 1995. BLM’s 2013 RFD projects up to 234 new wells could be developed on the PNG from 2013 through 2033. Lastly, drilling technology is advancing and changing how oil and gas resources are recovered.

Because FS leasing decisions should reflect consideration of environmental impacts, current technology, and current projected demand for oil and gas (among other things), the FS has identified the need to re-examine the 1997 leasing decision and make a new decision if necessary.

In addition, there is also a need for a leasing decision that best meets Forest Plan goals and objectives and geographic area direction for the PNG. The Forest Plan’s geographic area direction for the PNG is particularly important because it is specific to the PNG and helps “...specify priorities among competing uses, activities, resources, or other items.”²⁰ The extent

²⁰ See Forest Plan pg. 43 which discusses the purpose of geographic area direction.

to which the alternative leasing programs evaluated in this EIS meet Forest Plan direction will be important to this decision.

1.5.2. Purpose of Action

The purpose of the Proposed Action is to complete a Grassland-wide leasing analysis that complies with the Leasing Reform Act. The leasing analysis will establish an oil and gas program for the PNG that, along with other forest plan direction, will guide oil and gas lease sales on the PNG for the next 20 years. This analysis will determine: (1) what lands will be available on the Pawnee National Grassland for oil and gas leasing; and (2) what stipulations will be included on any future leases.

This analysis is required to meet regulatory requirements of 36 CFR 228.102, which established guidance for the process for oil and gas leasing on National Forest System lands in order to comply with the Leasing Reform Act.

1.6. Scope of this Analysis

The goal of this analysis is to inform the leasing decision for the Pawnee Grassland. It includes analysis of relevant environmental impacts to assist the Forest Supervisor in selecting an alternative that best meets the purpose and need. However, because a leasing decision does not, by itself, result in any on the ground oil and gas development, the EIS analysis relies on the RFD to assess environmental impacts. The analysis uses the RFD's assumptions and projections of the number of wells, disturbed sites, and acres of surface disturbance as a basis for forecasting environmental impacts.

While the RFD provides a reasonable projection of oil and gas development, there are limitations on the precision of this projection and assumptions are needed. First, it is not possible to estimate precisely where, when, or how oil and gas leases will be developed into the future on the PNG. These details are only known once a lease is purchased and the operator submits an APD that includes a drilling plan and SUPO to indicate when, where, and how a well will be drilled on a federal lease. Second, the magnitude of future demand for oil and gas resources is difficult to determine. And this influences the schedule for lease sales and the specifics of lease development. Third, the RFD projection assumes all potentially productive areas can be open under standard lease terms and conditions, except those areas designated as closed to leasing by law, regulation, or executive order. This assumption is unlikely for Forest Service lands given that additional stipulations were required in the 1997 Leasing Decision. For these reasons, the accuracy of environmental disclosure in this EIS is limited and definitive conclusions about environmental impacts are difficult to make. As a result, this EIS makes broad disclosures to inform the leasing analysis determinations.

Even though the EIS cannot provide for precise disclosure of environmental impacts of oil and gas development over the next 20 years, it does give an idea of what the general environmental

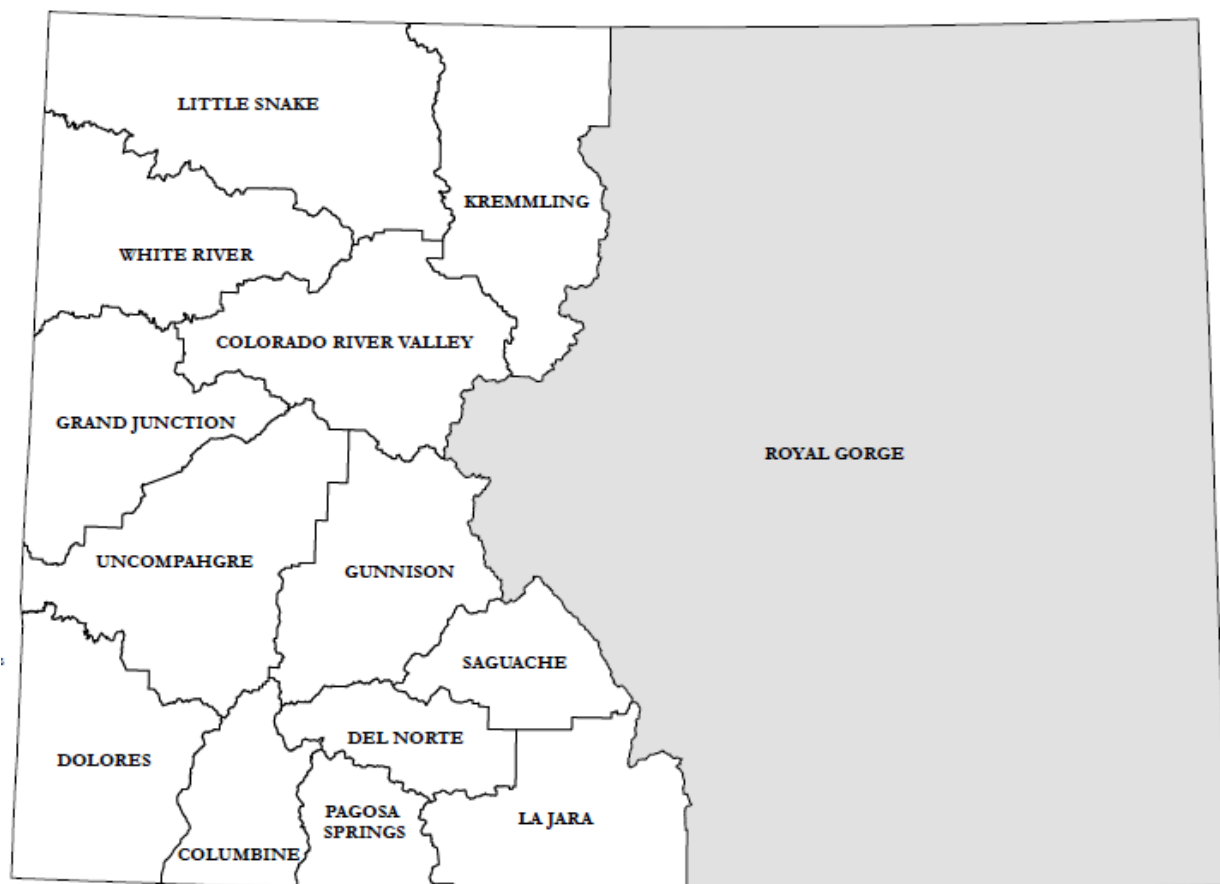
consequences of oil and gas development would be under alternative leasing programs. It also provides an opportunity to evaluate cumulative impacts more soundly than they could be evaluated under individual APD or SUPO analysis. Finally, this analysis is helpful to identify important resources on the PNG and provides a discussion of the risk, if any, from oil and gas development to those resources. All of this information is helpful in making the land availability and stipulation determinations for the leasing decision.

1.7. Reasonably Foreseeable Development (RFD)

Because this analysis uses the RFD as a basis for analysis, this section describes some of the most relevant projections and assumptions. This area includes most of eastern Colorado. The RFD provides a projection for lands within the BLM's Royal Gorge Field Office boundary (see Figure 1). This includes not just the PNG but private, state, and other non-federal lands; encompassing at total of 680,000 surface acres and 6.8 million sub-surface acres. The PNG includes about 192,000 acres of this total.

The entire RFD is included as Appendix A.

Figure 1—Royal Gorge Field Office



1.7.1. RFD Projections

The RFD consists of three primary projections: (1) the total number of wells expected in the Royal Gorge Planning Area; (2) the number of disturbed sites (i.e. well pads); and (3) the acres of surface disturbance.

The RFD includes projections for both short term and long term. There are two reasons for this. First, not all wells that are drilled will be productive and remain on the landscape. Those that are not productive are removed and the area is reclaimed. Second, the short term surface disturbance is much greater than long term surface disturbance because of reclamation requirements.

The short and long term RFD projections for wells, disturbed sites, and surface disturbance are displayed in Tables 1-6 below.

Table 1—Short Term RFD Well Projection.

	BLM Lands	PNG	Other Lands (state and private)	Total
Total New Exploratory and Development Wells	515	265	12,261	13,041
Total Existing Active Wells	490	245	28,262	28,997
Total Wells	1,005	510	40,523	42,038

Table 2—Long Term RFD Well Projection

	BLM Managed	PNG	Other Lands (state and private)	Total
Total New Active Wells	460	234	10,906	11,600
Total Remaining Active Wells	399	196	22,890	23,485

Total Wells	858	430	33,796	35,084
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Table 3—Short Term RFD Disturbed Sites Projection

	BLM Managed	PNG	Other Lands (state and private)	Total
Total New and Exploratory Well Disturbed Sites	374	170	8,198	8,742
Total Existing Disturbed Well Sites	399	196	23,509	24,104
Total Short-Term Disturbed Sites	773	366	31,707	32,846

Table 4—Long Term RFD Disturbed Sites Projection

	BLM Managed	PNG	Other Lands (state and private)	Total
Total New Active Disturbed Well Sites	338	154	7,407	7,899
Total Remaining Disturbed Well Sites	336	162	19,431	19,929
Total Long-Term Disturbed Sites	674	316	26,838	27,828

Table 5 RFD Short Term Surface Disturbance Projection (acres)

	BLM Managed	PNG	Other Lands (state and private)	Total
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Total New Acres of Surface Disturbance	1,741	935	41,764	44,440
Total Existing Surface Disturbance	453	228	26,141	26,822
Total Short Term Disturbance	2,194	1,163	26,838	71,262

Table 6—RFD Long Term Surface Disturbance Projection

	BLM Managed	PNG	Other Lands (state and private)	Total
Total New Acres of Surface Disturbance (after reclamation)	271	177	6,007	6455
Total Existing Surface Disturbance	315	151	18,182	18,648
Total Long Term Disturbance	586	278	24,240	25,104

1.7.2. RFD Assumptions

The RFD includes many assumptions in order to project oil and gas development and surface disturbance. These assumptions are described in more detail throughout the RFD (see Appendix A); however, a summary is provided below.

1.7.3. Projection Assumptions

- All potentially productive areas will be open under standard lease terms and conditions, except those areas designated as closed to leasing by law, regulation, or executive order
- Horizontal drilling will be primarily used for oil and gas development.
- The success rate for new wells will be very high—about 90%.
- Successful wells will be productive for 50 years.

1.7.4. Surface Disturbance Assumptions

- With increased drilling interest and increased interest in multi-pad wells in the Greater Wattenberg AQNAA, it is assumed that 70 percent of new wells will be

drilled on an average of four wells per pad. The remaining 30 percent of new wells will average one well per pad.

- It is assumed that in the area to the north of the Greater Wattenberg AQNAA, successful exploration and development will proceed with pads averaging at least three wells each and these pads will account for 50 percent of new wells drilled in the area. The remaining 50 percent of new wells will average one well per pad.
- In the rest of the Planning Area it is assume as many as five percent of new conventional wells will be drilled with an average of two wells per pad and the remaining 95 percent will average one well per pad.
- Pads with one well will have two acres of initial disturbance associated with the pad, 0.91 acres associated with a road, and 1.1 acres associated with a pipeline. If the well is not successful the pipeline disturbance will not occur. For productive wells the pad will be reclaimed to 0.25 acres, the road will be reclaimed to 0.43 acres, and the pipeline will be completely reclaimed.
- Pads with two wells will have four acres of initial disturbance associated with the pad, 0.91 acres associated with a road, and 1.1 acres associated with a pipeline. If the well is not successful the pipeline disturbance will not occur. For productive wells the pad will be reclaimed to 0.5 acres, the road will be reclaimed to 0.43 acres, and the pipeline will be completely reclaimed.
- Pads with three wells will have 10 acres of initial disturbance associated with the pad, 0.91 acres associated with a road, and 1.1 acres associated with a pipeline. If the well is not successful the pipeline disturbance will not occur. For productive wells the pad will be reclaimed to 0.7 acres, the road will be reclaimed to 0.43 acres, and the pipeline will be completely reclaimed.
- Pads with four wells will have 10 acres of initial disturbance associated with the pad, 0.91 acres associated with a road, and 1.1 acres associated with a pipeline. If the well is not successful the pipeline disturbance will not occur. For productive wells the pad will be reclaimed to 0.9 acres, the road will be reclaimed to 0.43 acres, and the pipeline will be completely reclaimed.
- Of the existing active wells (as of February 2012) 20 percent wells will be abandoned by the end of the Planning Period.

1.8. Decisions to be Made

The Arapaho Roosevelt National Forests and Pawnee National Grassland Supervisor will make a leasing decision. This decision will include a land availability determination and a lease stipulation determination. These determinations are described below:

(1) Land Availability Determination

The land availability determination specifies what lands will be administratively available for leasing. This decision will place NFS lands on the PNG into three categories:

- a) Available for leasing through management discretion
- b) Closed to leasing through management discretion
- c) Closed to leasing by law or regulation

(2) Lease Stipulation Determination

The lease stipulation determination identifies what lease stipulations will be attached to future leases on lands determined to be administratively available for leasing.

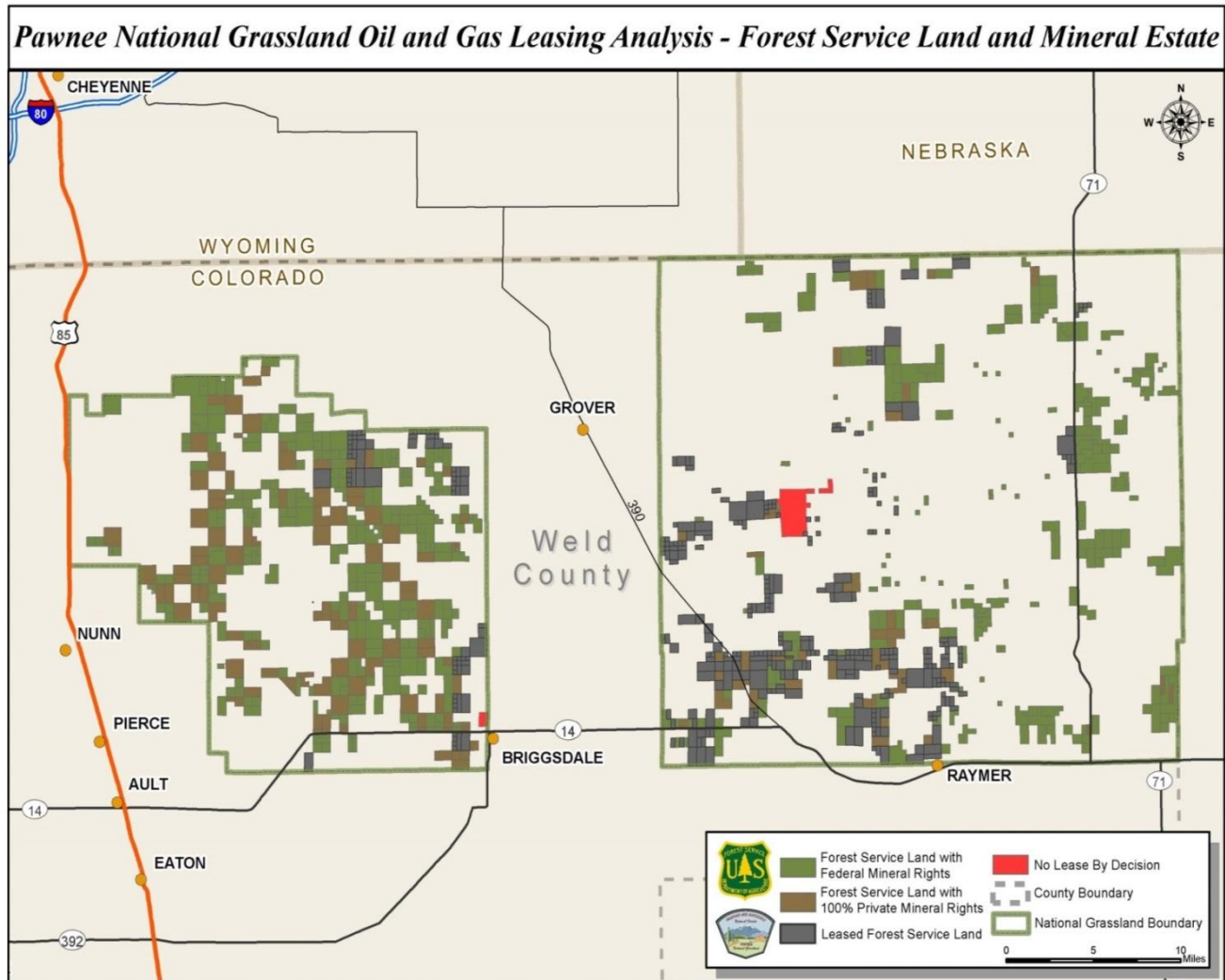
The leasing decision will be documented as an amendment to the Forest Plan. It will replace Appendix D—Oil and Gas Leasing Supplemental Stipulations.

1.9.Lands affected by this decision

The PNG is approximately 192,000 acres. However, this decision will only directly impact approximately 100,000 acres—the unleased federal mineral estate on the PNG.

There are two primary reasons for this. First, approximately 46,000 acres of the PNG lie above private mineral estate. Because the mineral estate is privately held, federal availability determinations and lease stipulations do not apply. Second, approximately 43,000 acres of the PNG are already leased. Because these lease rights are already granted, they will continue under their existing terms until they expire. However, if existing leases expire, the land availability and lease stipulation determinations under this decision will be included in any future leasing decisions on these lands.

Figure 2 Land and Mineral Estate



1.10. Public Participation

The Forest Service has invited the public to participate in the following ways:

- A notice of intent (NOI) to prepare an environmental impact statement was published in the Federal Register on April 1, 2013. The NOI requested comments and described the proposed action, purpose and need, decision to be made, and provided a contact for further information.
- A scoping letter was mailed to interested and affected individuals on April 2, 2013. This letter described the proposed action, purpose, and need, decision to be made and provided instructions on how to comment.

The Forest Service received about 3,000 comments.

1.11. Issues

Issues and concerns were identified from interdisciplinary team analysis and comments received during scoping. These issues and concerns are summarized below:

- Many respondents provided comments related to the impacts of hydraulic fracturing on groundwater, surface water, terrestrial wildlife, avian wildlife, soil, scenic, recreation, and air quality resources. They recommended that the EIS include disclosure of impacts to water rights, disposal of fluids, re-injection storage, the probability of leaks, the effects of leaks if they occur, and contamination avoidance measures were requested. Some comments included a recommendation that hydraulic fracturing be prohibited on the federal parcels of the project area. Other commenters recommended No Surface Occupancy (NSO) requirements on all remaining leasable lands on the Pawnee National Grassland.
- Several respondents provided comments related to the need for a thorough groundwater analysis that involves industry and science.
- A few respondents provided comments related to the benefits of horizontal or directional drilling with regard to minimizing environmental impacts. Some respondents also provided comments related to the limitations of directional drilling; the use of directional drilling must be determined on a case-by-case basis due to industry cost, control, and technical limitations.
- Some respondents provided comments related to soil degradation cause by increased road and pipeline construction to support the oil and gas operations.

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- Some respondents provided comments related to potential effects to wildlife species due to increased oil and gas operations and activity. The species listed included terrestrial, avian, and particularly sensitive and threatened species, either federally or state listed. These include: black-tailed prairie dogs, burrowing owls, swift fox, mountain plover, ferruginous hawk, long-billed curlew, Brewer's sparrow, McCowan's longspur, chestnut-collared longspur, grasshopper sparrow, and Brewer's sparrow. The potential effects could be caused by the development of roads and pipelines which can cause habitat fragmentation or degradation, edge effects, and direct mortality.
 - Some comments recommended stipulations in the Environmental Impact Statement (EIS) for: no oil and gas development adjacent to or in prairie dog towns; wild-to-wild relocation, which entails relocating prairie dogs from disturbed burrows to vacant burrows in alternate locations; reverse dispersal translocation (RDT), which entails coaxing prairie dogs out of an area and gradually closing down vacant burrows; and restricting vehicles from within active prairie dog colonies.
 - A few respondents provided comments related to negative effects on recreational activities due to increased oil and gas operations and activity. The potential reductions in bird species and populations, as well as visual obstructions caused by oil and gas equipment were cited as potential causes for a reduction in bird watching activity on the Grassland.

1.12. Issues Dismissed from Detailed Study

The following issues were dismissed from detailed study because they are either unaffected by a leasing decision or because these resources are not present on the PNG.

- Impacts on grazing allotments were dismissed from detailed study because the amount of surface disturbance under the alternatives is expected to have a negligible reduction in forage or exercise of grazing permits.
- Impacts on rare plants were dismissed from detailed study because no rare plants or rare plant habitat exists on the PNG.
- Impacts to paleontological resources are dismissed from detailed study because surveys will be required prior to any oil and gas development authorized on the PNG and any avoidance of undiscovered paleontological resources would be required as Conditions of Approval at the APD stage.
- Impacts to existing special use permits or authorizations were dismissed from detailed study because these authorizations primarily consist of underground pipelines and transmission lines. These authorizations are not expected to be amended or otherwise altered as a result of any potential future oil and gas development.

Pawnee Oil and Gas EIS Chapter 2

Introduction

This chapter describes the alternatives considered by the Forest Service for the leasing decision. It describes features common to all alternatives and a description of each alternative. Because a leasing decision involves determinations of lands available for leasing and leasing stipulations, the alternatives differ on what lands are available for leasing and what lease stipulations would apply to future leases. The alternative descriptions also include a discussion of reasonably foreseeable future development under each alternative.

In addition, to describing the alternatives, this chapter also includes:

- (1) The Forest Service's preferred alternative and the reasons for that preference.
- (2) A description of alternatives considered but dismissed from detailed study and the reasons why they were dismissed.
- (3) A summary of the environmental impacts of the alternatives in comparison format. This summary is drawn from the findings and analysis in Chapter 3 of this FEIS.

2. Alternatives Considered in Detail

This FEIS considers three alternatives in detail:

- Alternative 1-No Leasing Alternative
- Alternative 2-No Action Alternative
- Alternative 3-No Surface Occupancy Alternative (NSO Alternative)

These alternatives all have different combinations of PNG lands available for leasing and lease stipulations. However, there are some portions of the PNG that are unlikely to be affected by any of the alternatives.

The PNG includes about 46,000 acres of private mineral estate that is located underneath Forest Service surface estate. These lands are unaffected by the availability and stipulation determinations in the alternatives because a leasing decision only applies to the federal mineral estate. Even though the Forest Surface manages the surface estate, it does not have the authority to determine whether private mineral rights are leased or what terms are included in leases. The Forest Service negotiates with private mineral estate holders to manage the NFS surface estate to be as close as possible to the standards used for federal minerals.

The PNG also includes about 43,000 acres of existing federal leases. These leases include stipulations that were determined in the 1997 Forest Plan and are identical to those described in the No Action Alternative. The Forest Service does not have the authority to cancel existing leases or replace existing lease stipulations with new stipulations. For this reason, this analysis assumed existing stipulations remain on existing leases.

It is possible that existing leases could expire and be leased again. If this happens, the availability and stipulation determinations in the alternatives would apply. Although this is a possibility, it is very unlikely. This is because the Niobrara formation is a “proven” field and over the past 20 years it has been extremely rare that a lease expires and is leased again. For this reason, the FEIS assumes that, for all the alternatives, existing leases will continue under their current terms.

2.1.No Leasing Alternative

Under the No Leasing Alternative, none of the unleased portion of the PNG would be available for lease. Because lands would be unavailable for leasing, there are no leasing stipulations on these lands. This alternative is required by regulation 36 CFR 228.102(c)(2)

2.1.1. Lands Available for Leasing and Stipulations

Under the No Leasing Alternative, approximately 100,000 unleased acres of the PNG would not be leased. In addition, the 43,000 acres of existing leases, if they expired, would not be leased in the future. Existing leases would be developed according to the stipulations identified in the 1997 Forest Plan.

Table 7 Summary of Acres of Available for Development under No Leasing Alternative

Acres Available for Lease	0
Acres of Existing Leases	43,000
Acres of PNG with Private Mineral Estate	46,000
Total Acres Available for Development on the PNG	89,000

2.1.2. Reasonably Foreseeable Future Development

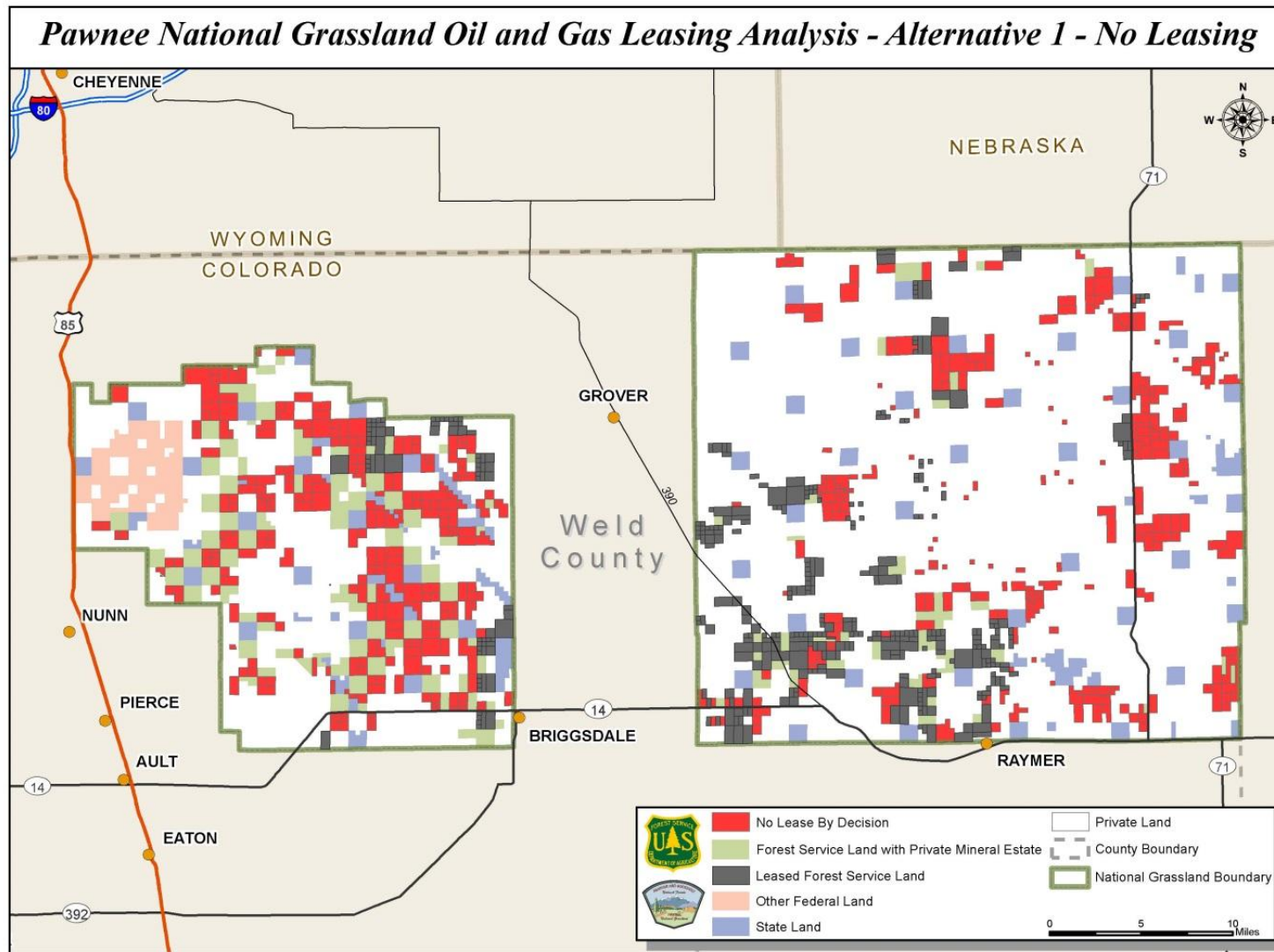
Under the No Leasing Alternative, there will be no well pads or wells located on the unleased portion of the PNG because none of the unleased portion of the PNG will be available for lease. Therefore, there will be zero acres of surface disturbance on those lands.

However, oil and gas development will probably continue in the area despite 100,000 acres of the PNG being unavailable for lease. It is likely that adjacent private and non-federal lands will be developed. In addition, it is likely that existing leases on the PNG will also be developed.

If oil and gas development continues on these lands, it must avoid drilling through the unleased portions of the PNG. Avoiding these areas is estimated to result in about 10% more surface disturbance, wells, and well pads than projected under the RFD. This is because additional oil and gas development infrastructure is needed to avoid unleased lands while developing non-federal leases (*see* EIS section 3.11 for further discussion).

It is expected that development on adjacent non-federal lands, private lands, and leased federal lands will result in approximately 1,279 acres of short term surface disturbance and 305 acres of long term surface disturbance. Approximately 292 new and exploratory wells would be drilled and; of those wells, 257 producing wells would remain in the long term. Surface disturbance and wells would be located on non-federal lands adjacent to the PNG, lands above private mineral estate on the PNG, and on existing leases on the PNG.

Figure 3 No Leasing Alternative



2.2. No Action Alternative

Under the No Action Alternative, the land availability and stipulation determinations made during the 1997 Forest Plan Revision would continue. This means that approximately all of the PNG would be available for lease except for 2,980 acres. These 2,980 acres include the Pawnee Buttes Area (2,740 acres) and the Crow Valley Campground (240 acres).

Table 8 Summary of Acres Available for Development under the No Action Alternative

Acres Available for Lease	100,000
Acres of Existing Leases	43,000
Acres of PNG with Private Mineral Estate	46,000
Total Acres Available for Development on the PNG	189,000

The stipulations identified in the 1997 Forest Plan would be included on any future leases (see Appendix B). These stipulations apply to either specific lands on the PNG or when certain resource conditions are present. For example, a No Surface Occupancy for active ferruginous hawks nests applies if an active nest is located on the lease; whereas, a timing limitation for mountain plover applies to any of the 143,000 acres of federal leases on the PNG.

Table 9 Existing Forest Plan Stipulations

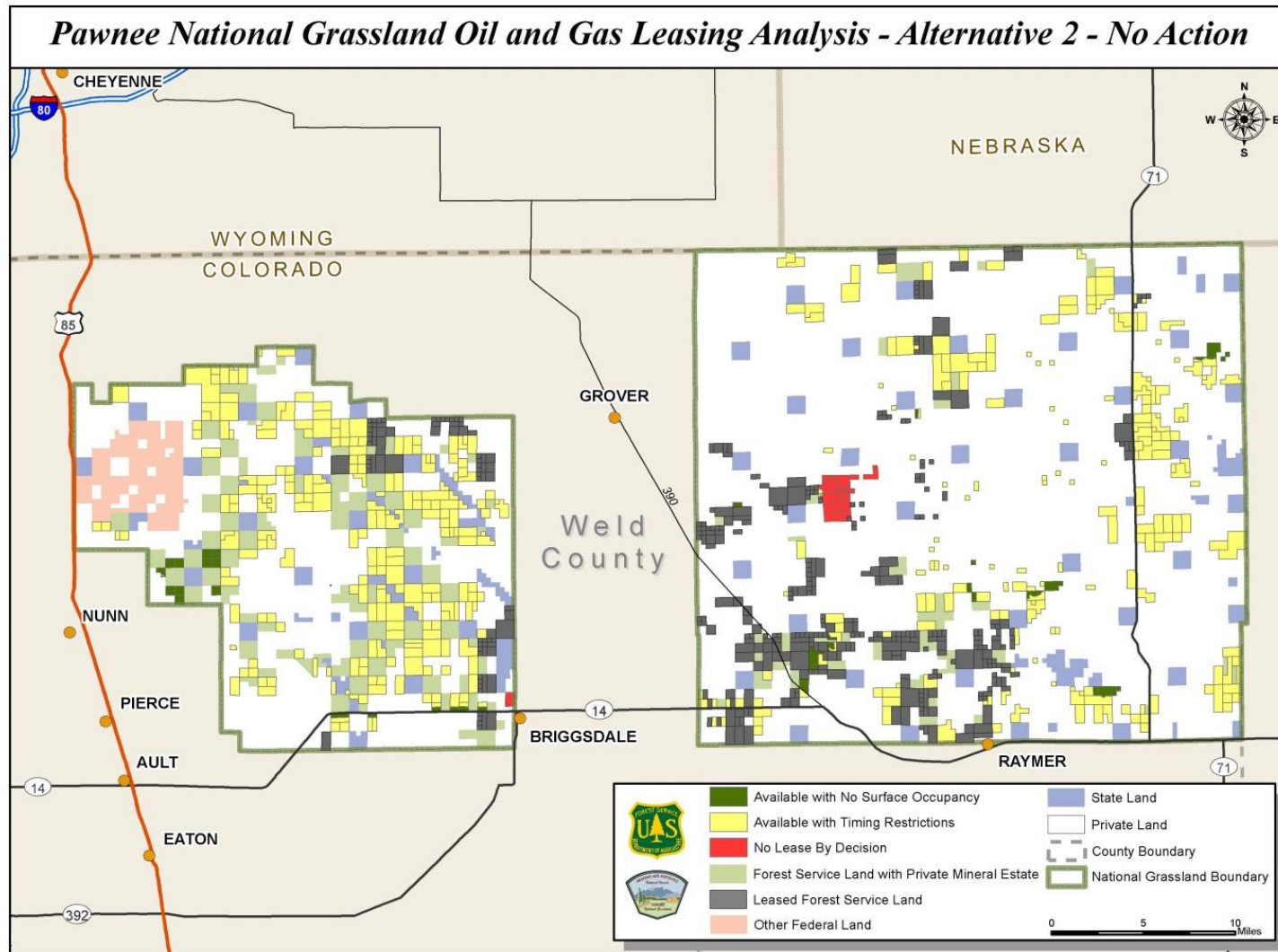
Stipulation	Resource	Time Period	Area Covered	Buffer Distance
Timing Limitation	Mountain plover	April 10- July 10	143,000 acres	N/A
Timing Limitation	Active raptor nests	March 1- June 30	N/A	500 meters of active raptor nests
No Surface Occupancy	Active nests of bald eagles, golden eagles, ferruginous hawks, Swainsons's hawks, and red-tailed hawks	Year round	N/A	500 meters from active nests
No Surface Occupancy	Active nest of prairie falcons	Year round	N/A	200 meters of the top of cliffs and 400 meters from the bottom of cliffs containing active nests.
No Surface	Prairie Woodlands	Year round	1,339	N/A

Occupancy			acres	
No Surface Occupancy	Research Natural Areas and Special Interest Areas	Year round	7,300	N/A
Controlled Surface Use	Soils/Slopes	Year round	408 acres	N/A

2.2.1. Reasonably Foreseeable Future Development

Under the No Action Alternative, it is likely that a portion of unleased lands, currently leased lands, and private mineral estate on the PNG will have oil and gas development. Under the RFD, the projection is for approximately 935 acres of short term surface disturbance and 177 acres of long term surface disturbance on the PNG. Approximately 265 new and exploratory wells would be drilled. Of those wells, 234 producing wells would remain in the long term.

Figure 4 No Action Alternative



2.3.No Surface Occupancy Alternative

The No Surface Occupancy Alternative (NSO Alternative) will allow nearly all lands on the PNG to be available for lease. The exception is the Pawnee Buttes and Crow Valley Campground areas—2,980 acres.

Table 10 Summary of Acres Available for Development under the No Surface Occupancy Alternative

Acres Available for Lease	100,000
Acres of Existing Leases	43,000
Acres of PNG with Private Mineral Estate	46,000
Total Acres Available for Development on the PNG	189,000

Under this alternative, all 100,000 unleased acres of the PNG will include a NSO stipulation. This stipulation would prohibit wells and well pads from being located on the lease. The 43,000 acres of existing leases would continue under the stipulations determined in the 1997 Forest Plan Revision unless the lease is released by the lease holder. Those stipulations are summarized in Table 9 under the No Action Alternative.

Table 11 Summary of Stipulations on Federal Mineral Leases under the No Surface Occupancy Alternative

Stipulation	Resource	Area Covered
No Surface Occupancy	Wildlife, Hydrology, Fisheries, Scenery, and Recreation	100,000 acres
1997 Forest Plan Stipulations	Wildlife, Management Area Direction, Soils/Slopes, and Prairie Woodlands	43,000 acres

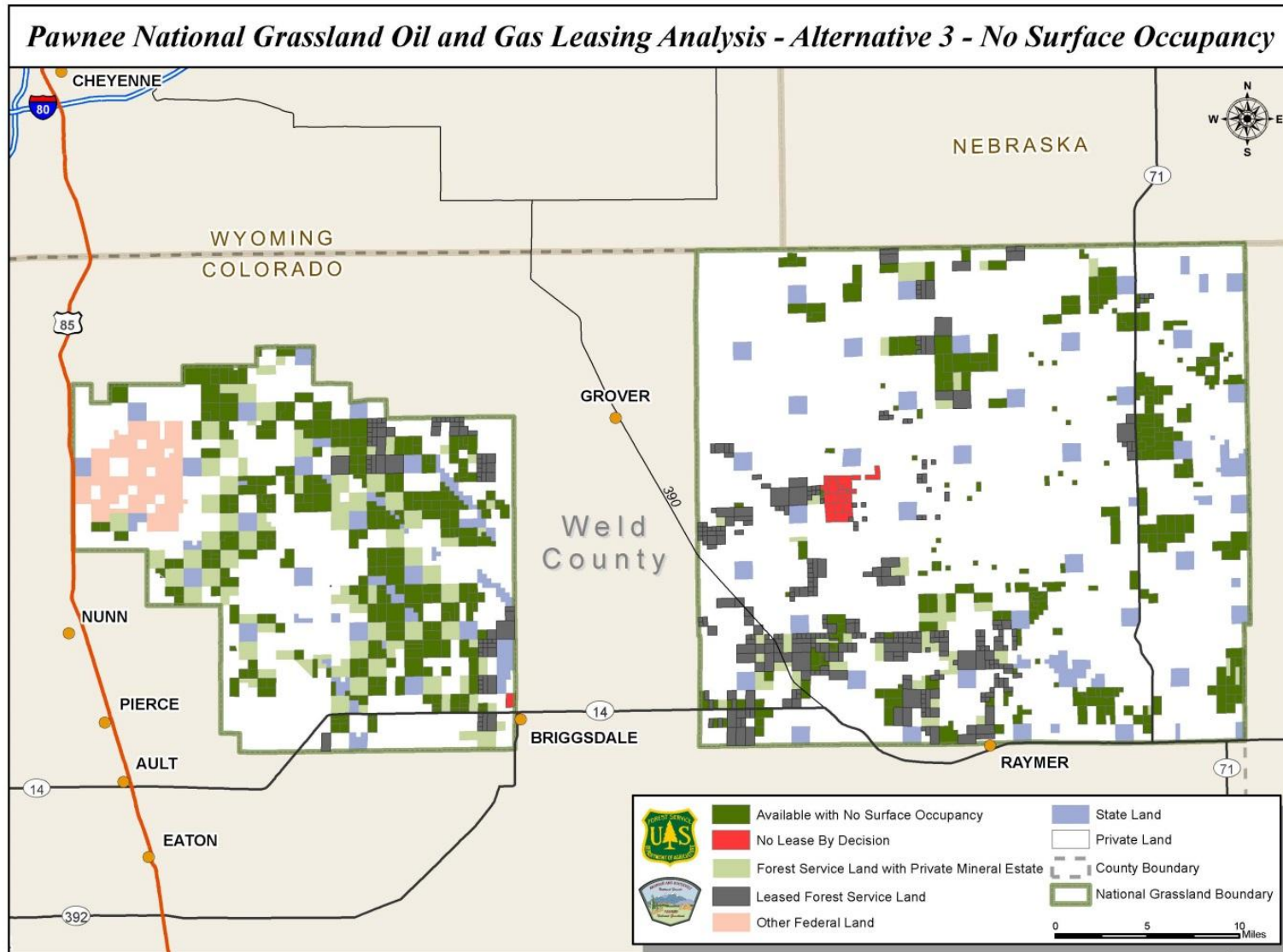
2.3.1. Reasonably Foreseeable Future Development

Under the NSO Alternative, no wells, well pads, or surface disturbance is expected on the 100,000 unleased acres on the PNG because lease stipulations will prohibit surface occupancy. However, similar to the No Leasing Alternative, oil and gas development is still expected to occur on already leased lands, private mineral estate, and adjacent private lands. If leases are sold on the 100,000 acres of the PNG, it is likely that oil and gas operators will locate well pads and wells on primarily private lands and horizontally drill into their leases.

Unlike Alternative 1, where operators must avoid federal leases, the NSO alternative would allow leases to be sold. As a result, the increase in surface disturbance, wells, and well pads under the No Lease Alternative is not expected under the NSO Alternative. Therefore, the

projection for surface disturbance and wells is the same as under the No Action Alternative. However, all surface disturbance and wells associated with these leases would be located on private adjacent lands.

Figure 5 No Surface Occupancy Alternative



2.4. Summary Comparison of Alternatives

The alternatives differ in the amount of land available for leasing and what stipulations will be included on those leases. These determinations are most immediately relevant to the unleased portion of the PNG. This is because these lands (if available) could be nominated for lease sales in the immediate future. The portions of the PNG with existing leases are likely to continue under their terms and private mineral estate is not subject to federal leasing analysis.

Table 12 compares the alternatives in availability and lease stipulations for the 100,000 acres of unleased land on the PNG.

Table 12 Land Available for Leasing and Stipulations for Unleased Portion of PNG

Alternative	Acres Available for Leasing	Acres Unavailable for Leasing	Stipulations
No Leasing	0	102,980	None
No Action	100,000	2,980	1997 Forest Plan Stipulations
No Surface Occupancy	100,000	2,980	No Surface Occupancy

In order to get a complete picture of the lands available for leasing and lease stipulations across the entire PNG, Table 13 includes already leased lands and private mineral estate. This table assumes that private mineral estate holders will make leases available.

Table 13 Total PNG Acres Available for Leasing and Applicable Stipulations

Alternative	Total Acres Available for Development	Total Acres Unavailable for Leasing	Stipulations	
No Leasing	89,000	100,000	Existing Leases	1997 Forest Plan stipulations
			Private Minerals	None
			Unleased	None
No Action	189,000	2,980	Existing Leases	1997 Forest Plan stipulations
			Private Minerals	None
			Unleased	1997 Forest Plan stipulations
No Surface Occupancy	189,000	2,980	Existing Leases	1997 Forest Plan stipulations
			Private Minerals	None
			Unleased	No Surface Occupancy

2.5. Forest Service Preferred Alternative

The NSO Alternative is the Forest Service's preferred alternative.

The Forest Service prefers this alternative because it allows for extraction of nearly all the oil and gas resources while providing the most protection of surface resources and providing opportunities for other multiple uses. Because horizontal drilling is expected to be used for nearly all wells, it is possible to access the mineral estate without occupancy directly above the leasehold. For this reason, even if a lease contains a NSO stipulation, it is expected that nearly all the oil and gas can be recovered and that stipulations do not meaningfully influence recoverability.

This alternative also results in no surface disturbance of the unleased portion of the PNG and the fewest projected wells and well pads. While the No Leasing Alternative prohibits the sale of federal leases (and occupancy of the PNG), this alternative results in more surface disturbance, wells, and well pads on adjacent private lands. In addition, it does not provide any oil and gas resources on the unleased portion of the PNG.

2.6. Alternatives Considered but Dismissed from Detailed Study

The Forest Service also considered six additional alternatives, but dismissed them from detailed study. These alternatives were developed by during the NEPA analysis or brought forward by commenters during the comment period on the FEIS. These alternatives and the reasons they were dismissed are described below.

2.6.1. Leasing under Standard Lease Terms

This alternative would make nearly all lands available for leasing on the PNG. The unleased portion of the PNG would be subject to only standard lease terms (SLTs). In other words, there would be no resource specific stipulations on unleased lands.

This alternative was dismissed for detailed study because SLTs will not provide sufficient protection of resources or met Forest Plan goals and objectives. For several resources, stipulations that allow the Forest Service to relocate oil and gas development more than 200 meters and restrict operations more than 60 days are necessary. For example, buffers beyond 200 meters are needed to protect nests and timing windows beyond 60 days are necessary to mountain plover. In addition, there are several resources where a no surface occupancy stipulation was necessary.

2.6.2. Leasing with Additional Resource Stipulations

This alternative would make nearly all lands available for leasing on the PNG. This alternative included all stipulations identified in the 1997 Forest Plan and additional resource specific stipulations for wildlife, hydrology, cultural resources, fisheries, and scenery.

This alternative was dismissed from detailed study because it is very similar to the NSO Alternative which is already considered in detail. Taken together, the stipulations under this alternative resulted in a majority of the PNG being subject to an NSO stipulation. Because the NSO Alternative is already being considered in detail, this alternative was dismissed from detailed analysis. In addition, oil and gas recoverability was identical to the NSO Alternative and there was no tradeoff identified that would warrant the risk to surface resources on the small portion of non-NSO lands.

2.6.3. Alternative that designates a portion of the PNG as unavailable for leasing and a portion that is available, but subject to an NSO stipulation

This alternative was dismissed from detailed study because it will result in greater risk to surface resources (i.e. more wells and well pads) without any benefit to oil and gas recovery. This is because not leasing PNG lands is expected to result in greater oil and gas development than leasing. The FEIS includes an analysis of four townships on both the east and west sides of the PNG comparing development with and without leasing. The analysis indicates that between 10-50% more surface disturbance is associated when the PNG is not leased (see FEIS pp. 41-48).

The essence of Forest Service mineral policy is to encourage energy development in an ecologically sound manner. This alternative will result in federal minerals being lost, while increasing surface disturbance and environmental impacts. Although the increase in development and loss of minerals will be less than the No Leasing Alternative,²¹ it is contrary to Forest Service minerals policy and the purpose and need (see EIS pp. 8-9).

2.6.4. Alternative that adds additional resource based stipulations to the NSO alternative

This alternative was dismissed from detailed study because its environmental impacts will be identical to the NSO Alternative. Under the NSO Alternative, no wells or well pads can be located on the leasehold. Identifying stipulations; such as, timing limitations or controlled surface use, are unnecessary because wells and well pads are prohibited from being located on the entire leasehold. For example, adding a timing limitation (e.g. construction cannot occur in August) is not necessary when construction is already prohibited altogether and year round. In addition, Forest Service leasing regulations are only applicable to leases on National Forest

²¹ Forest Service leasing regulations at 36 CFR 228.102 requires the Forest Service analyze an alternative that does not allow leasing. For this reason it was included for detailed study.

System lands and to operations that are conducted on Federal oil and gas leases on National Forest System lands.²²

2.6.5. Alternative that prohibits hydraulic fracturing on the PNG and within 3 miles of its borders

This alternative was dismissed from detailed study because it is outside of the Forest Service's authority. The Forest Service does not have authority over whether non-Forest Service lands can be leased. In addition, the FEIS includes an analysis of a No Leasing Alternative.

2.6.6. Alternative with two separate leasing decisions—one for the east side and one for the west side of the PNG

This alternative was dismissed from detailed study because the FEIS includes a leasing analysis for the entire PNG. While the west side of the PNG contains more contiguous Forest Service lands than the east side and may require longer lateral drilling, the oil and gas is still recoverable regardless of stipulations on surface occupancy. It is not clear how two leasing decisions would be any different than analyzing both areas under one leasing decision.

²² See 36 CFR 228.100(b).

2.7. Summary of Environmental Impacts by Alternative

The following summarizes the environmental impacts of the three alternatives considered in detail.

Table 14 Summary Comparison Table

Resource	Resource Subcategory	No Leasing Alternative	No Action Alternative	No Surface Occupancy Alternative
<u>Wildlife</u>	Forest Service Sensitive Species	May impact individuals but is not likely to result in a loss of viability in the planning area or cause a trend in federal listing	May impact individuals but is not likely to result in a loss of viability in the planning area or cause a trend in federal listing	May impact individuals but is not likely to result in a loss of viability in the planning area or cause a trend in federal listing
	Forest Service Management Indicator Species	Neutral influence on most species habitat and neutral influence on local population	Negative influence on most species habitat and negative influence on local population	Neutral influence on habitat and neutral influence on local population
<u>Hydrology</u>		Moderate Risk	Moderate/High Risk	Low Risk
<u>Air</u>		Low	Low	Low
<u>Fisheries</u>	Forest Service Sensitive Species	May impact individuals but is not likely to result in a loss of viability in the planning area or cause a trend in federal listing	Likely to result in a loss of viability in the Planning Area, or in a trend toward federal listing	May impact individuals but is not likely to result in a loss of viability in the planning area or cause a trend in federal listing
	Management Indicator Species	Slightly negative effect on individuals and populations	Negative effect on individuals and populations	Slightly negative effect on individuals and populations
<u>Fluid Minerals</u>		0% recovery of oil and gas resources (178 million barrels of oil and 356 MCF of gas will be produced from existing leases)	100% recovery of oil and gas resources (590 million barrels of oil and 1180 MCF of gas will be produced from existing and unleased lands)	100% recovery of oil and gas resources (590 million barrels of oil and 1180 MCF of gas will be produced from existing and unleased lands)
Heritage		Significant Impacts	Significant Impacts	No Significant

		to Cultural Resources	to Cultural Resources	Impacts to Cultural Resources
<u>Recreation</u>		Low	High	Low
<u>Scenery</u>		Moderate/Low	Moderate	Low
<u>Economics</u>	Federal Revenues	72.8M	242M	242M
	State Revenues	120M	408M	408M
	Weld County Revenues	55M	223M	223M

Pawnee Oil and Gas EIS Chapter 3

Introduction

This chapter describes the environmental impacts of the alternatives. It provides analysis on current resource conditions and a prediction of the environmental impacts of the alternatives on those conditions. The aim is to provide an understanding of what the environmental impacts will be and how those impacts compare across alternatives. Section 2.7, at the end of Chapter 2, includes a summary and comparison of those impacts; however, this chapter explains in more detail how the Forest Service arrived at those conclusions.

Environmental impacts are organized under specific affected resources. However, this chapter also includes a general discussion of the environmental impacts of oil and gas development. This discussion is included because predicting environmental impacts of oil and gas development for a leasing decision does not involve any specific proposal for development. Because no specific proposal is available, this general discussion lays the foundation of the overarching environmental impacts that are discussed in more detail under each resource. It also helps to identify some of the common environmental concerns about oil and gas development.

In addition, this chapter also includes a description of the common terms and typical stages of oil and gas development to assist in understanding impacts.

This chapter also includes a discussion of primary assumptions about how future oil and gas development may occur under the alternatives. While the RFD provides a projection of the amount of oil and gas that could occur if the PNG was entirely available for lease under standard leasing terms, none of the alternatives propose this. As a result, this EIS makes assumptions on how the RFD projection applies to the alternatives. It also makes assumptions on how oil and gas development could occur (i.e. what a likely APD and SUPO would propose). Because the environmental impacts of oil and gas development are contingent on both the amount and specifics of development, these assumptions influence how the environmental impacts disclosed.

3.1 Oil and Gas Development

In order to understand the environmental impacts of oil and gas development, this section provides a broad overview development of an oil and gas lease. Oil and gas development usually follow a staged process. These stages are described below.

Mineral Leasing

During the mineral leasing stage, companies acquire leases that allow for oil and gas development. For federal minerals, these leases specify stipulations on where and when development of leases may occur.

The Forest Service’s leasing analysis and decision determines what lands are available for lease and what stipulations are included in any leases sold.

Permits

When a federal lease is purchased, the operator must obtain a permit from BLM authorizing the drilling of a well. This permit is referred to as an APD. The APD includes both a surface use and drilling plan. These plans are evaluated under NEPA and may require site-specific environmental protection measures (sometimes referred to as “Conditions of Approval”). These measures address specific elements of the APD and enhance protection of resources that may be impacted by development of the lease.

Roads and Pad Construction

Once all permits are obtained, roads are usually constructed to access the well site and well pads are developed. Well pads are constructed in order to accommodate the drilling rig and other equipment during the drilling process.

Figure 6 Example of Well Pad Construction



Drilling

The drilling rig drills the well. A steel pipe casing is placed into the hole and cemented in place. Once the casing is cemented in place, a perforating gun with shaped explosive charges is lowered into the rock layer containing oil and natural gas. The perforating gun is fired and creates perforations in the rock layer which connects the reservoir and the well.

Figure 7 Example of Drilling



Hydraulic Fracturing

Hydraulic fracturing fluids are pumped under high pressure into the formation. The fluid consists primarily of water but also include sand and other chemicals. These fluids create fractures in the perforations that allow oil and gas to flow into the well bore.

Figure 8 Example of Hydraulic Fracturing



Production

After hydraulic fracturing is completed, the well is placed into production. A producing well does not require a drilling rig and other infrastructure needed for drilling and fracturing. Therefore, the parts of the well pad that are no longer needed are reclaimed. A well may stay in production for between 30 and 50 years.

Figure 9 Example Producing Well with Interim Reclamation Completed



Maintenance

Once a well is in production, it may require periodic cleaning, repair, or maintenance over the course of its productive life.

Plugging and Abandonment

Once all of the oil and gas that can be recovered economically has been reached, it is plugged and abandoned. Plugging consists of filling the casing with cement and the well is cut off between three and six feet below the surface and buried. The remaining surface disturbance; including well pads and access roads, are reclaimed back to native vegetation.

3.2 General Environmental Concerns or Impacts of Oil and Gas Development and Hydraulic Fracturing

The environmental impacts of oil and gas development ultimately depend upon location, formation, surface use development, and many other factors. However, there are several potential impacts that are commonly voiced with oil and gas development. These impacts and concerns are described below in order to provide context for the resource and PNG specific discussion of environmental impacts in Sections 3.6 through 3.17.

Groundwater and Surface Water Contamination

There is possibility that hydraulic fracturing poses a risk of water contamination.²³ Contamination is potentially due to three possibilities. First, hydraulic fracturing may produce fissures that allow fluids to migrate into water sources. Second, the well casing might fail; allowing fluids to escape into underground drinking water. Third, accidental spills at the surface could contaminate surface water or seep into groundwater.

Migration

Migration involves the possibility that hydraulic fracturing fluids have the potential to travel through fissures into water sources. Because a percentage of fluids remain underground upon completion of the hydraulic fracturing process, some concern has been raised that these fluids will migrate into drinking water sources.

Although risk from migration is possible, this risk is limited for two reasons. First, any fluids left behind are likely to be isolated far below any ground water sources and the force of gravity makes it unlikely that these fluids would migrate upward into groundwater sources. Second, in most cases there is over a mile of impermeable rock that separates oil and gas targets from ground water.

Casing or Cement

Improper casing or cementing can create a possibility that hydraulic fracturing fluids or natural gas can migrate into ground water and properly drilling and casing a well is one of the most important aspects for protecting water resources. The most commonly reported instance of casing failure is when improper casing or cementing allows methane to enter groundwater. One study from MIT noted that, of 43 publically reported incidents related to gas well drilling, 20 were related to contamination of groundwater by natural gas.²⁴

While contamination of groundwater is uncommon; there are reported occurrences. However, there is no definitive conclusion of how common this occurs and estimates range from 7% to .03% with varying levels of supporting analysis. Regardless of how likely contamination of groundwater due to improper cementing or casing is; in general,

²³ For example, at the request of Congress, EPA is “conducting a study to better understand any potential impacts of hydraulic fracturing for oil and gas on drinking water resources.” Results of this study are not available; however, a draft report is expected in early 2015. See <http://www2.epa.gov/hfstudy>.

²⁴ See “The Future of Natural Gas.” Available at: <http://mitei.mit.edu/publications/reports-studies/future-natural-gas>

the more oil and gas wells, the greater the likelihood that improper casing may cause groundwater contamination.

Surface Spills

Hydraulic fracturing fluids, oil, gasoline, and other chemicals are handled above ground before and after injection. This creates a contamination risk from spills, run-off, or seepage. Spills are somewhat common in oil and gas development. Of the 43 publically reported incidents, 14 were related to surface spills. In addition, the Colorado Oil and Gas Conservation Commission (COGCC) maintains a database of spills.²⁵ Using this database, it has been reported that during 2014 there were an average of two spills per day in Colorado, 521 from January 2014 through July 2014, and 575 in 2013.²⁶ In addition, some of these spills affected groundwater and surface water.

Surface spills can pose environmental risk. Spills have the potential to contaminate both surface and groundwater and, depending on the chemicals, can render soil unsuitable for vegetative growth. Spills that contaminate surface water can also pose a risk to aquatic species.

The magnitude of risk and impacts will depend on several factors; including, cleanup and remediation efforts, where the spill occurs, and how much fluid is spilt. However, in general, the more oil and gas development, the greater the risk that spills and associated impacts will occur.

Wildlife

Oil and gas development necessarily involves surface disturbance and traffic. As a general matter, any increase in surface disturbance and traffic adversely affects wildlife and their habitat. This can be either because habitat is reduced because of construction of roads and well pads or because wildlife does not tolerate traffic and human activity. In addition, surface spills involving surface waters can harm aquatic species.

Surface disturbance with oil and gas development differs between the short term and long term. The short term surface disturbance associated with constructing a well pad and drilling the well is much greater than the long term disturbance for a producing well. This is because of reclamation. For example, a pad with four wells is expected to have a short term surface disturbance of 12 acres; however, once the well is producing, approximately 11 acres can be reclaimed.

The degree of impact to wildlife depends on many factors; including, habitat prevalence, current health of the species, length of disturbance, and individual species tolerance for

²⁵ See COGCC database at: <http://cogcc.state.co.us/>

²⁶ See Denver Post at: http://www.denverpost.com/environment/ci_26233762/oil-and-gas-spills-surge-three-day-residents

disturbance. In addition, the location of well pads or roads is critical. However, as a general matter, the less surface disturbance and traffic the less risk of impacts to wildlife.

Air Quality

Oil and gas operations contribute to air pollution by emitting carbon dioxide and other pollutants into the air. Gas powered compressors and vehicle traffic to and from well pads emit carbon dioxide and other pollutants. In addition, oil and gas development results in the emissions of criteria pollutants, including carbon monoxide, nitrogen oxides, sulfur dioxide, particulate matter, and volatile organic compounds (VOCs). With respect to VOCs, EPA has found that the oil and gas industry is the largest industrial source of these emissions.²⁷

While emissions are a fact of life in oil and gas development, there are initiatives or best management practices available to both industry and federal permitting agencies. For example, the EPA's Natural Gas STAR Program is voluntary program that encourages oil and natural gas companies to adopt cost-effective technologies and practices that improve operational efficiency and reduce emissions of methane.²⁸ BLM also has developed air resource best management practices that can be required as Conditions of Approval for any permit to drill.²⁹

In addition, the Clean Air Act (CAA) gives EPA the authority to set limits on certain air pollutants; including limits on how much can be in the air anywhere in the United States. The CAA also gives EPA the authority to limit emissions of air pollutants coming from certain sources.³⁰ The EPA recently adopted New Source Performance Standards specific to the oil and gas industry. Therefore, regardless of the level of oil and gas development proposed or projected, the CAA provides some assurance that federal permitting of oil and gas development will not cause these limits to be exceeded.

3.3 Why No Leasing results in more surface disturbance, wells, and well pads.

The FEIS concludes that No Leasing results in the greatest total surface disturbance, wells, and well pads of all the alternatives. This is because the No Leasing creates inefficiencies in the drilling plan. Due to the checker-board land pattern, the No Leasing alternative results in shorter

²⁷ See EPA Basic Information on Oil and Natural Gas Air Pollution Standards. Available at: <http://www.epa.gov/airquality/oilandgas/basic.html>

²⁸ See EPA Natural Gas STAR program. Available at: <http://www.epa.gov/gasstar/>

²⁹ See BLM Air Resource BMPs and Comprehensive Air Resource Protection Protocol (CARRP). Available at: http://www.blm.gov/pgdata/etc/medialib/blm/wo/MINERALS_REALTY_AND_RESOURCE_PROTECTION/_bmps.Par.60203.File.dat/WO1_Air%20Resource_BMP_Slideshow%2005-09-2011.pdf
http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5436475.pdf

³⁰ These standards are available at: <http://www.gpo.gov/fdsys/pkg/FR-2012-08-16/pdf/2012-16806.pdf>

horizontal wells and an increase in the number of wells, well pads, pipeline, and roads to avoid the federal mineral acreage and still develop the interspersed fee mineral acreage.

Because it is somewhat counterintuitive why making federal mineral estate unavailable for leasing results in more oil and gas infrastructure than leasing, an analysis comparing development was completed. The analysis projects how oil and gas development will occur—with and without federal leasing—on four townships on the PNG. The analysis includes townships on both the east and west portions of the PNG. Based on the analysis, surface disturbance increases between 10% to 50% when comparing the No Leasing Alternative to the NSO Alternative.

The assumptions for this analysis include:

- The horizontal laterals can reach approximately 2 miles.
- There are between six to eight wells per pad.
- Wells are drilled in the North-South direction.
- The oil in place was 70 million barrels of oil (MMBO) per section with a 7.5% recovery factor.
- The federal royalty was 12.5%
- The commodity price was based on the average crude oil prices for the past year in the DJ Basin from Plains Marketing, LP (i.e., \$85 per barrel).
- The surface disturbance was based on the RFD with 10 acres of pad disturbance per pad, 0.91 acres of road disturbance per pad, and 1.1 acres of pipeline per pad.
- Current and planned development was not examined during this review. The review was to determine the approximate range of disturbance possible based on real examples of the checker-board pattern of mineral ownership and the current development would have lowered the average since there are current inefficiencies in the current development due to unleased minerals.

Figure 10 Well and pad analysis for the No Leasing Alternative in T. 9 N. R. 58 W.

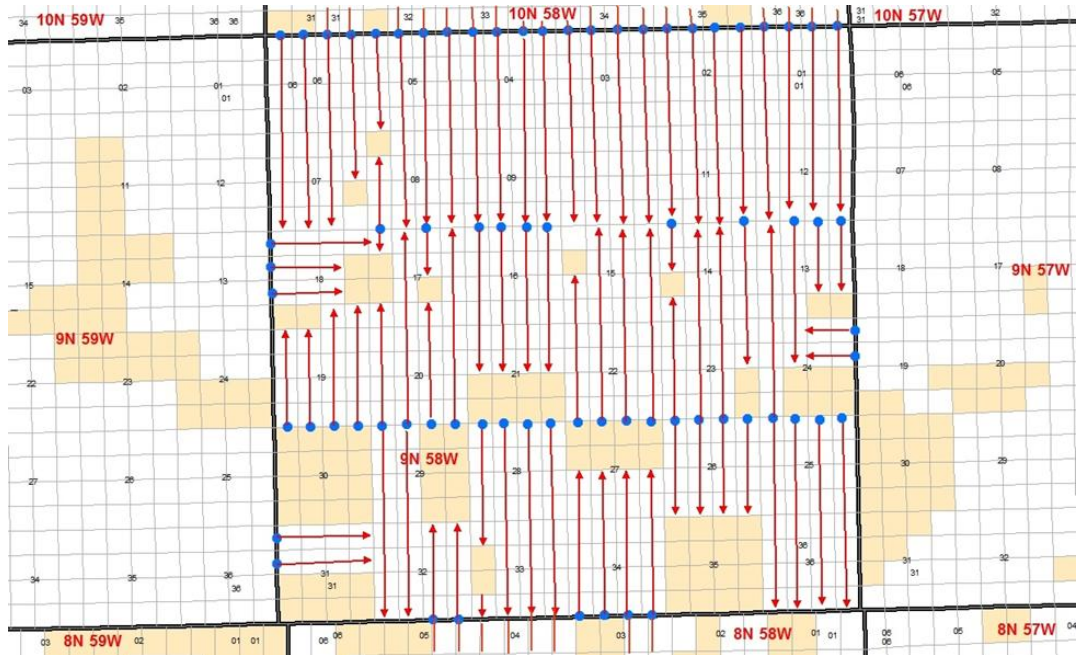
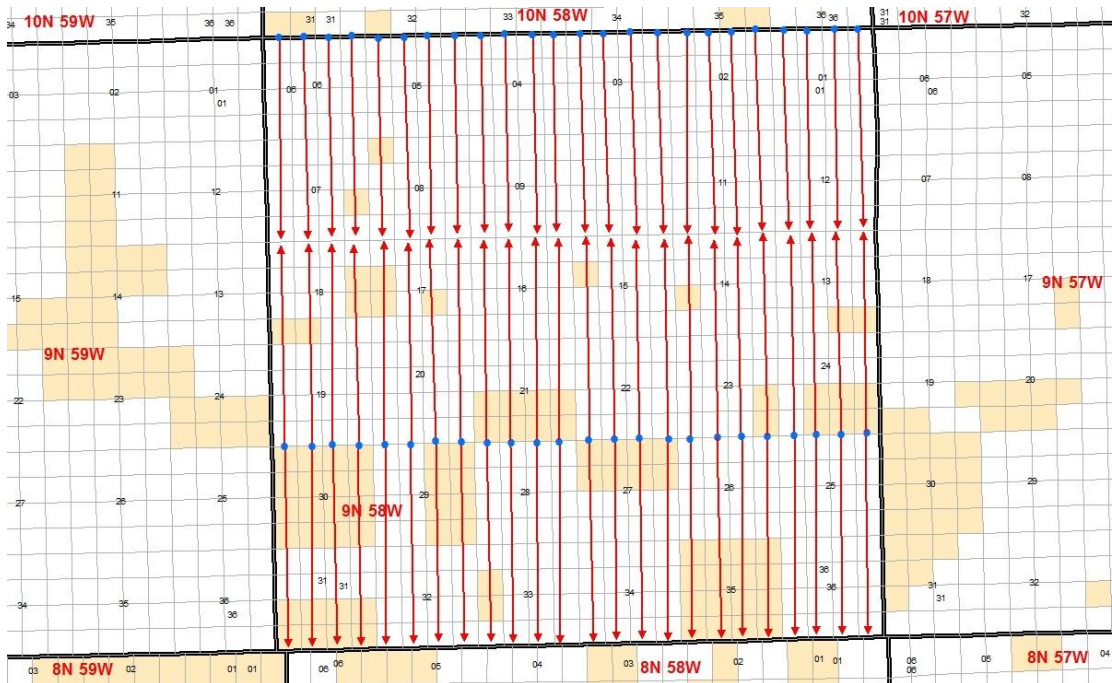


Figure 11 Well and pad analysis for the NSO alternative in T. 9 N. R. 58 W.



Based on the above review of the Township, **Error! Reference source not found.** summarizes the impacts on surface disturbance for the No Leasing and NSO alternatives.

Table 15. Summary of the theoretical impacts from the No Leasing and NSO alternatives in T. 9 N. R. 58 W.

	Alt. 1: No Leasing	Alt. 3: NSO
No. of Pads	72	48
Acres Disturbed	864.7	576.5
Recoverable Reserves (MMBO)	160.4	188.9
Federal Production Lost (MMBO)	28.5	0.0
Federal Royalty from Unleased Federal Minerals	\$0	\$303,195,000

Based on the review of T. 9 N. R. 58 W., the surface disturbance increases by 50% when the No Leasing alternative is compared to the NSO alternative.

Figure 12 Well and pad analysis for the No Leasing alternative in T. 9 N. R. 58 W.

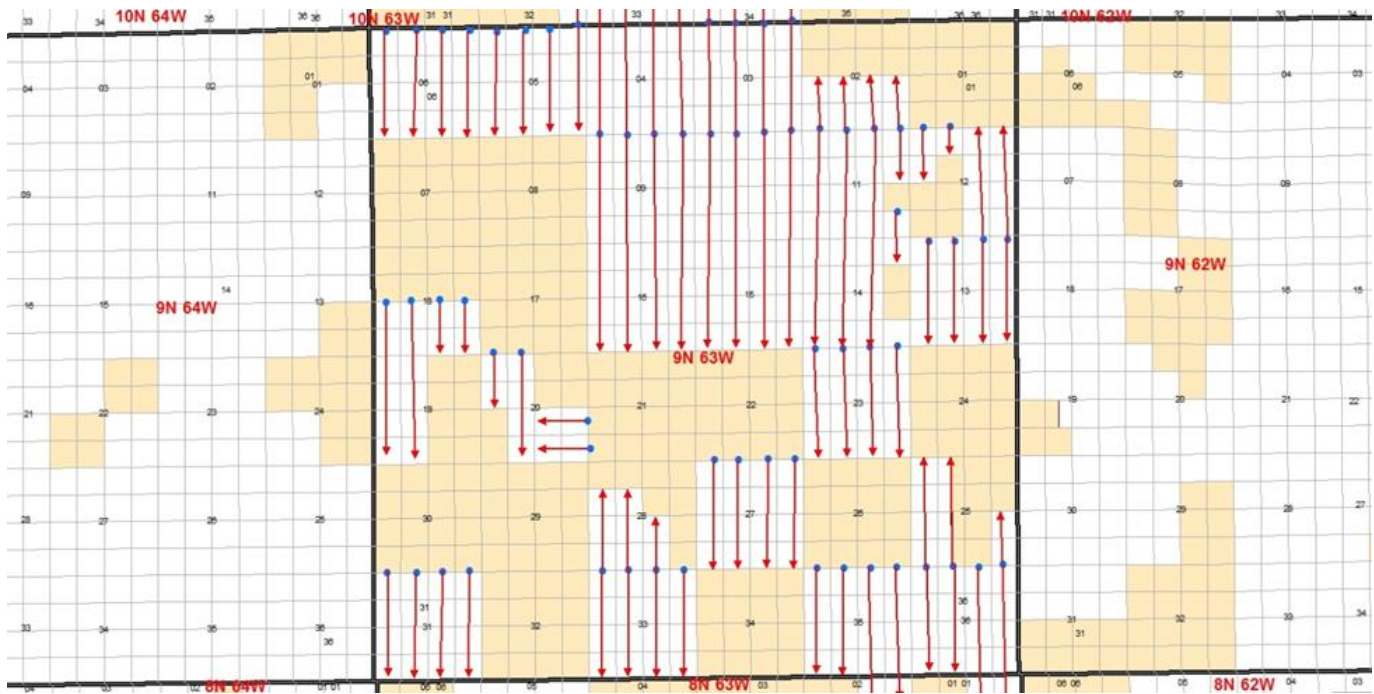
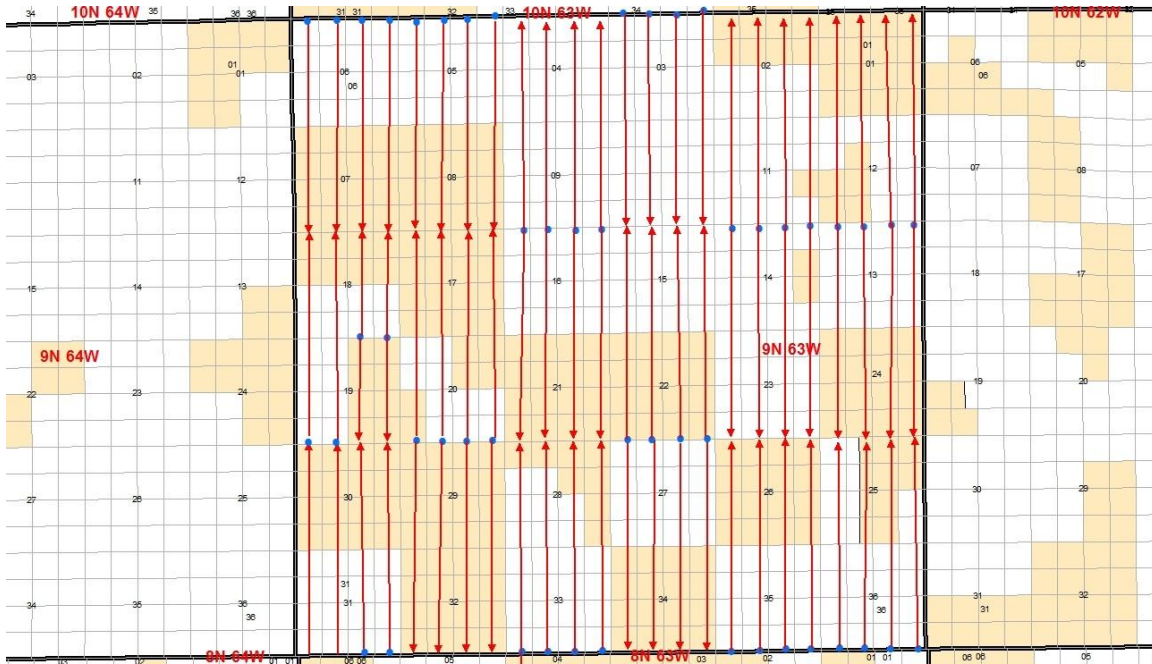


Figure 13 Well and pad analysis for the NSO alternative in T. 9 N. R. 63 W.



Based on the above review of the Township, Table 2 summarizes the impacts on surface disturbance for the No Leasing and NSO alternatives.

Table 16. Summary of the theoretical impacts from the No Leasing and NSO alternatives in T. 9 N. R. 63 W.

	Alt. 1: No Leasing	Alt. 3: NSO
No. of Pads	55	52
Acres Disturbed	660.6	624.5
Recoverable Reserves (MMBO)	105.1	188.9
Federal Production Lost (MMBO)	83.8	0.0
Federal Royalty from Unleased Federal Minerals	\$0	\$890,417,500

Based on the review of T. 9 N. R. 63 W., the surface disturbance increases by 15% when the No Leasing alternative is compared to the NSO alternative.

Figure 14 Well and pad analysis for the No Leasing alternative in T. 9 N. R. 64 W.

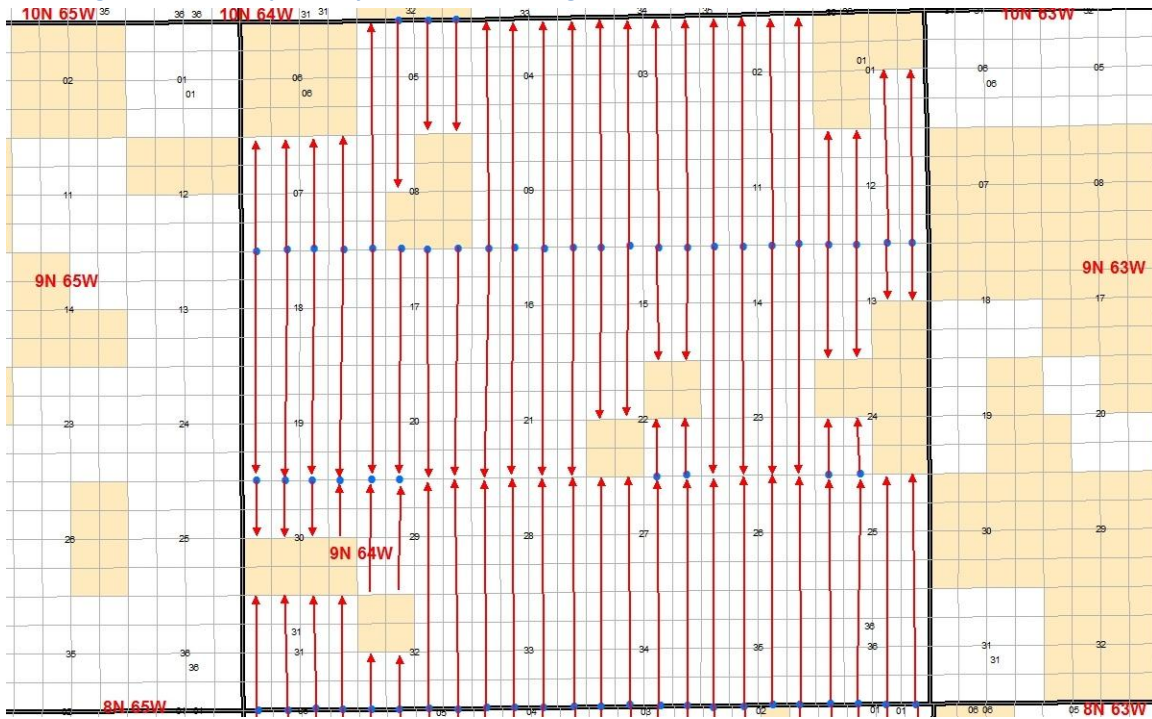
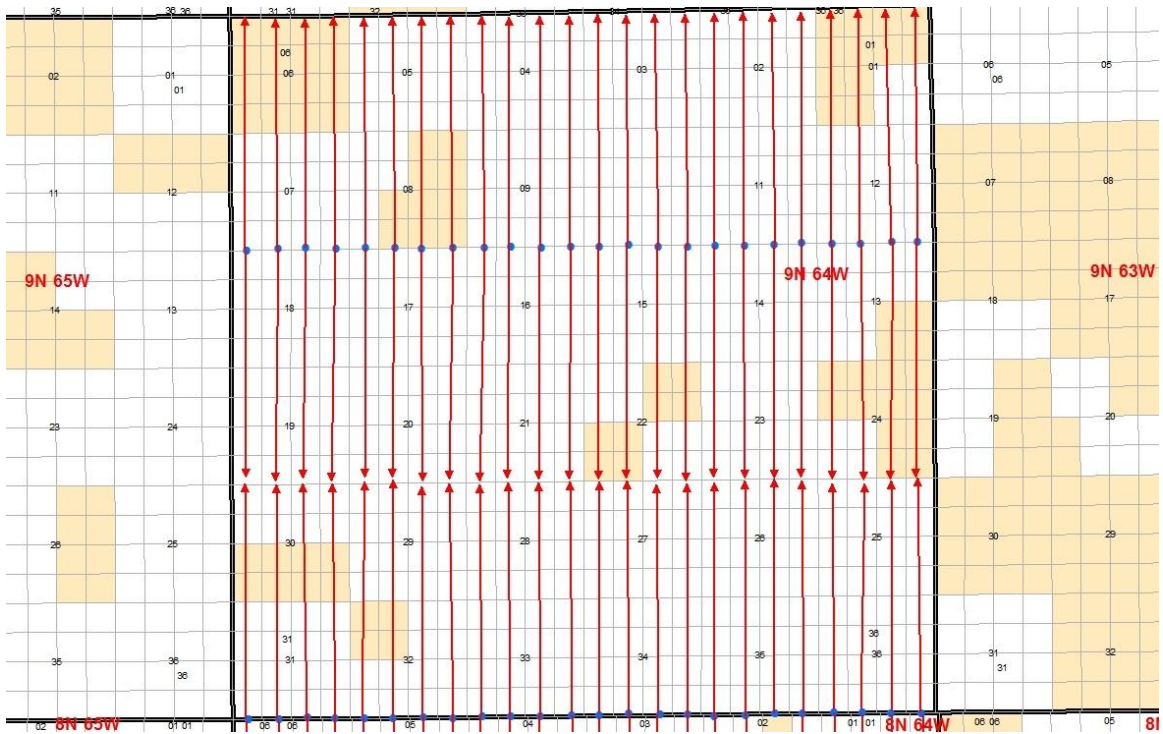


Figure 15 Well and pad analysis for the NSO alternative in T. 9 N. R. 64 W.



Based on the above review of the Township, Table 3 summarizes the impacts on surface disturbance for the No Leasing and NSO alternatives.

Table 17. Summary of the theoretical impacts from the No Leasing and NSO alternatives in T. 9 N. R. 64 W.

	Alt. 1: No Leasing	Alt. 3: NSO
No. of Pads	61	48
Acres Disturbed	732.6	576.5
Recoverable Reserves (MMBO)	164.7	188.9
Federal Production Lost (MMBO)	24.3	0.0
Federal Royalty from Unleased Federal Minerals	\$0	\$257,890,000

Based on the review of T. 9 N. R. 64 W., the surface disturbance increases by 27% when the No Leasing alternative is compared to the NSO alternative.

Figure 16 Well and pad analysis for the No Leasing alternative in T. 9 N. R. 65 W.

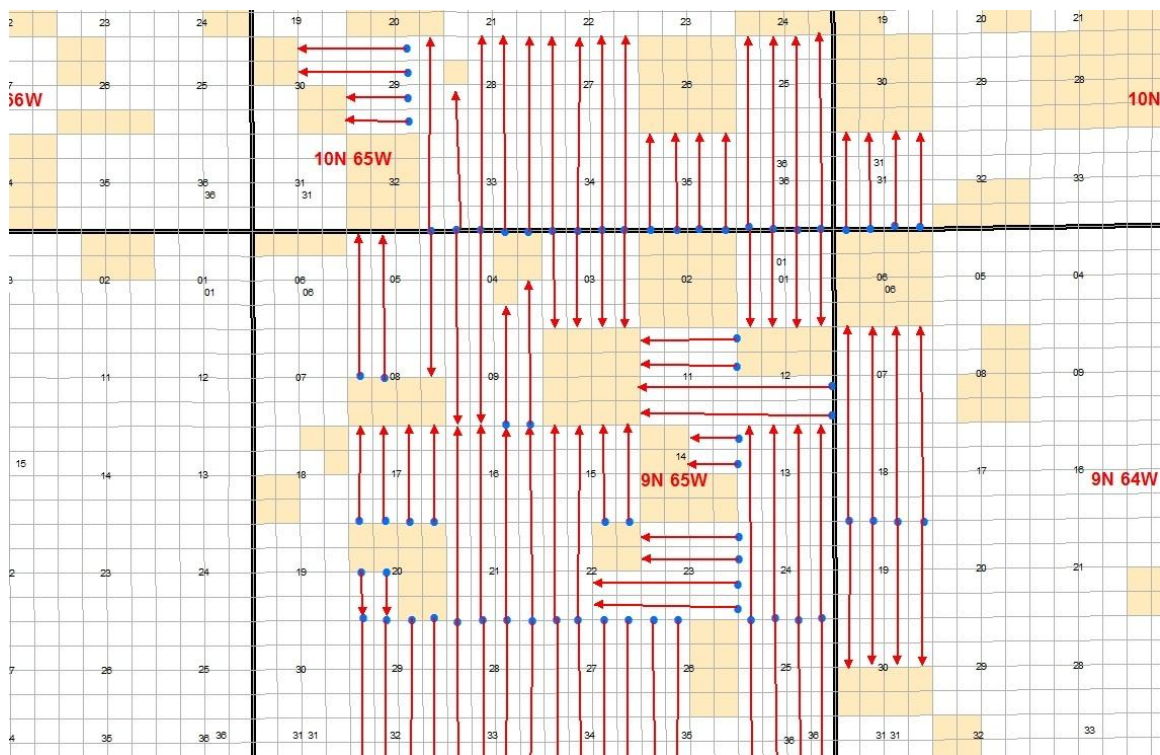
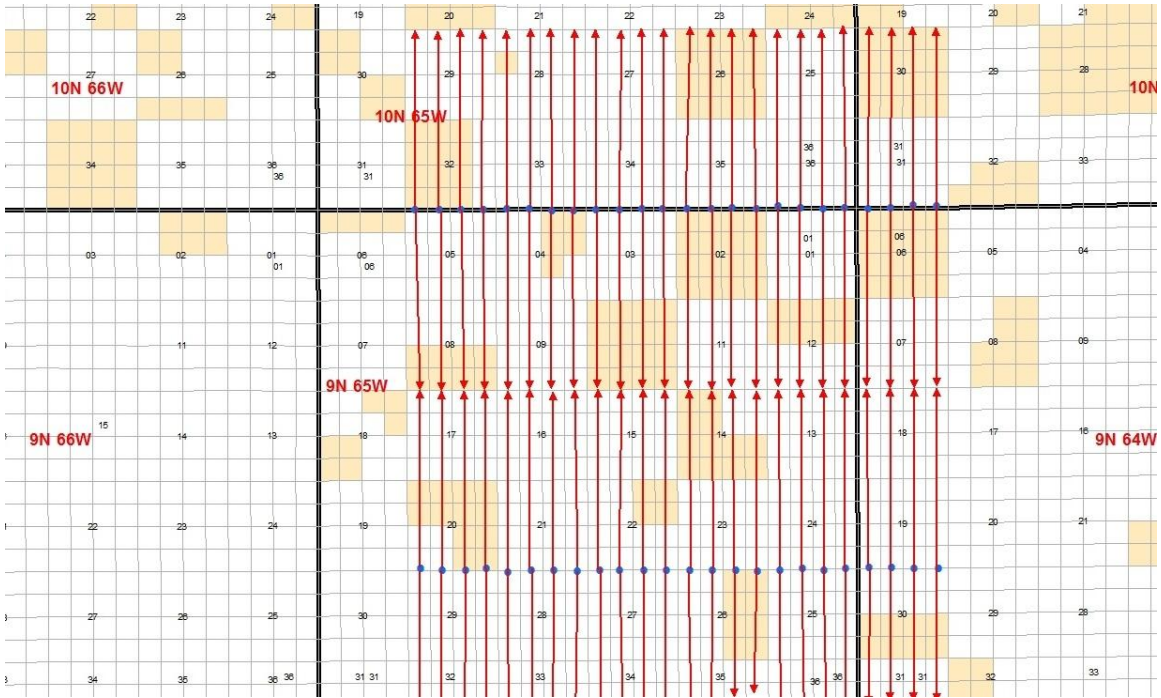


Figure 17 Well and pad analysis for the NSO alternative in T. 9 N. R. 65 W.



Based on the above review of the Township, Table 4 summarizes the impacts on surface disturbance for the No Leasing and NSO alternatives.

Table 18. Summary of the theoretical impacts from the No Leasing and NSO alternatives in T. 9 N. R. 65 W.

	Alt. 1: No Leasing	Alt. 3: NSO
No. of Pads	69	48
Acres Disturbed	828.7	576.5
Recoverable Reserves (MMBO)	142.2	188.9
Federal Production Lost (MMBO)	46.7	0.0
Federal Royalty from Unleased Federal Minerals	\$0	\$496,612,500

Based on the review of T. 9 N. R. 64 W., the surface disturbance increases by 44% when the No Leasing alternative is compared to the NSO alternative.

Summary

The four different townships include both smaller scattered tracts and larger more consolidated tracts of federal minerals. This analysis concludes that the anticipated additional surface disturbance varies from between 10% to 50% more surface disturbance with the No Leasing alternative.

3.4 Incomplete and Unavailable Information

Forecasting environmental impacts of projected oil and gas development necessarily involves imperfect information. There are two specific challenges to disclosing the environmental impacts for a leasing decision.

- (1) At the time a leasing analysis and decision is made, there are no specific proposals for oil and gas development to evaluate. It is unknown precisely where or how development will occur. In addition, APDs are subject to an additional NEPA process where Conditions of Approval are determined, which greatly influence environmental impacts. These details are critical to disclosing the actual impacts of oil and gas development.
- (2) There are no conclusive or definitive studies or consensus on the risk or environmental impacts of unconventional oil and gas wells. While there are numerous studies have assessed the impacts of shale gas development, not all of the environmental effects are clear.³¹

3.5 Assumptions

This section identifies the primary assumptions used for the analysis. These assumptions mainly relate to where and how oil and gas development may occur under the alternatives.

- (1) The Forest Service will have little, if any, control over use of the surface above private mineral estate within the PNG.
- (2) The No Leasing Alternative will result in about 10% more wells, well pads, and surface disturbance because of additional infrastructure needed to avoid unleased areas.
- (3) The No Leasing Alternative and NSO Alternative will likely result in well pads being located on adjacent private lands, but it's not determinable exactly where.
- (4) In the short-term (less than 1 year) a typical well pad will disturb 12 total acres (10 acres for the well pad, 1 acre for the road, and 1 acre for the pipeline). In the long term (after 1 year) a typical well pad will disturb 1.5 acres (1 acre for the pad, .5 acres for the road, and zero for the pipeline—because it's buried underground).
- (5) Existing leases on NFS lands will be developed according to the 1997 Forest Plan Stipulations.
- (6) All new productive wells will be on the landscape for between 30 to 50 years.
- (7) Horizontal drilling will almost exclusively be used to access oil and gas.
- (8) The success rate for wells is very high—between 87 and 90 percent.
- (9) Reclamation will occur for all oil and gas development—regardless of whether it is on NFS or non-NFS lands.

³¹ The Secretary of Energy Advisory Board (SEAB) published a 90-day report recognizing there is “...great merit to creating a national database to link as many sources of public information as possible with respect to shale gas development and production. Much information has been generated over the past ten years by state and federal regulatory agencies. Providing ways to link various databases and, where possible, assemble data in a comparable format, which are now in perhaps a hundred different locations, would permit easier access to data sets by interested parties.” Available at: http://www.shalegas.energy.gov/resources/111811_final_report.pdf

-
- (10) Oil and Gas development will occur under COGCC rules regardless of whether it occurs on NFS or non-NFS lands. If development is on NFS lands with federal mineral estate, it will also be subject to federal lease stipulations and BLM Conditions of Approval.

3.6 Affected Environment and Environmental Consequences

The following sections describe the affected environment and environmental consequences of the alternatives. These sections are organized around the specific resources analyzed in this EIS.

3.7 Hydrology and Soils Resources

Overview of Issues Addressed

1. Areas where surface water and groundwater resources are susceptible to degradation
 - a. Indicators: acres available for development with high risk to surface water and groundwater resources.
2. Areas with soils that have high erosion potential and are near streams, lakes, springs, wetlands, floodplains, and riparian areas (including riparian veg).
 - a. Indicators: acres available for development with high erosion potential or near to water resources.

Desired Condition

The goal of the Forest Plan is to improve and protect watershed conditions to provide the water quality and soil productivity necessary to support ecological functions and beneficial uses of water. In the desired future condition:

- State standards for water quality are attained and habitat condition supports the designated beneficial uses.
- Total watershed disturbance, measured by the amount of riparian disturbance and connected disturbed area, is limited to a level that maintains or improves stream health.

3.7.1 Affected Environment/Existing Condition

Introduction

The Pawnee National Grassland (PNG) is located in Northeastern Colorado. It is on the east side of the Continental Divide and in the rain shadow of the Rocky Mountains. The area is in the Central Shortgrass Prairie ecoregion (Wohl et al., 2009). The climate is semi-arid (SGS-LTER, 2010). The landscape is dominated by gently rolling hills with gentle gradient slopes (average slope gradient is <7%). The northern part of the grassland has high bluffs, arroyos, and box gullies. The valleys and swales range from broad-bottom to narrow down-cut shapes.

Dominant plant species include blue grama grass, threeawn grass, fringed sage, rabbitbrush, snakeweed, ring muhly, prickly pear cactus, western wheatgrass, scurf pea, sand sage, soapweed, and scarlet globemallow. Several aquatic plants are located in wetlands, including sandbar willow and cottonwood trees. These are located along some riparian corridors. There are also some juniper trees located in the Northern region of the grassland (Wohl et al., 2009).

Watersheds

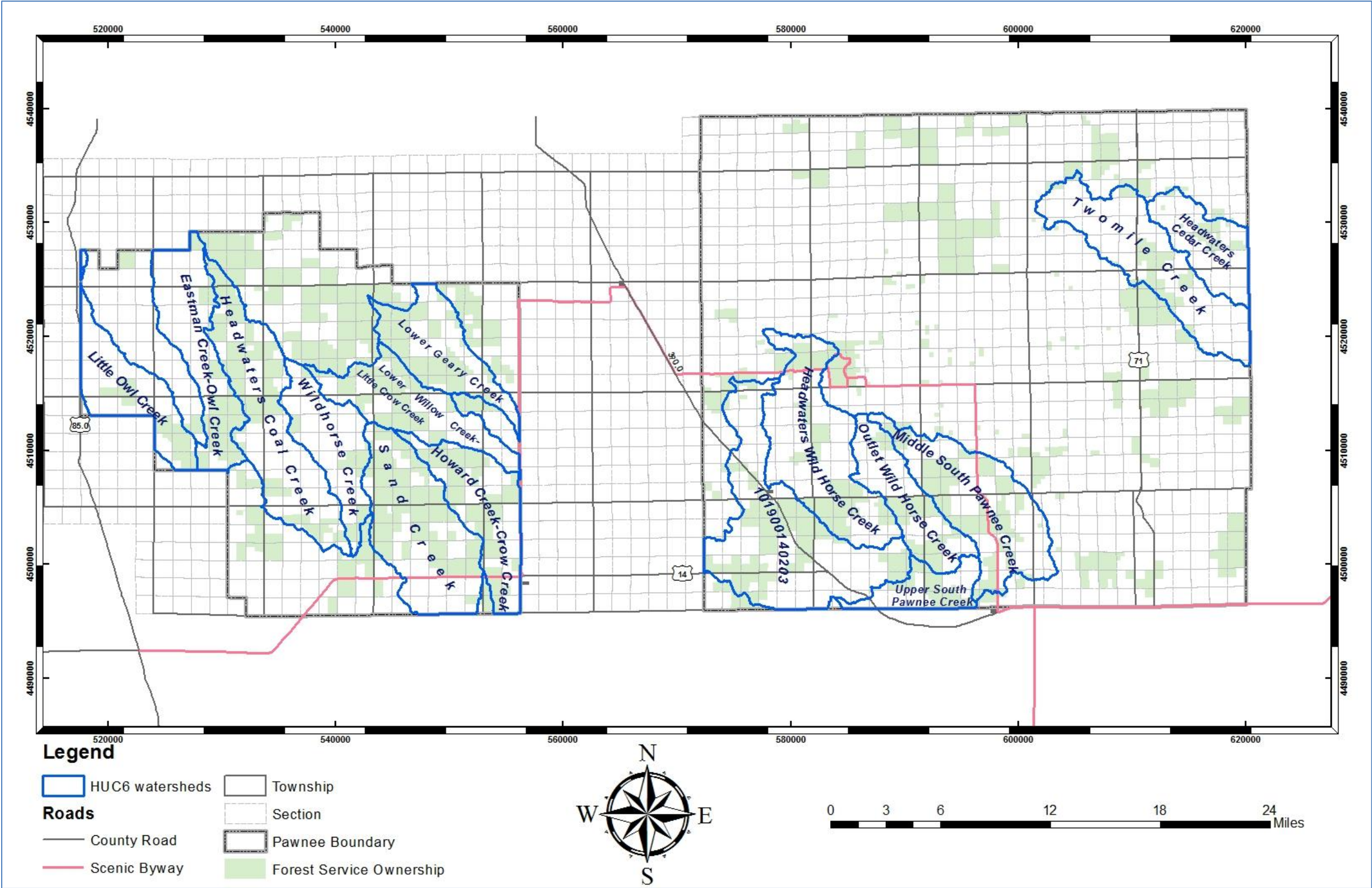
The Hydrologic Unit Code (HUC) system is used nationally to code watersheds from largest (HUC2) to smallest (HUC6). The HUC6 number is the watershed's HUC number, 6th level. A HUC 6 watershed has a size range from 5,000 to 40,000 acres. FS managed lands on the PNG falls within 39 HUC 6 watersheds. The watersheds where the majority of FS lands with important hydrologic resources occur are listed in Table 15 and shown in Figure 6.

Table 19 HUC6 watersheds representing 60% of FS lands on the PNG

HUC 6 WS name/#	WS size (acres)	Acres/% FS lands in WS	Watershed Condition Class (WCC)
WEST SIDE			
Little Owl Creek/ 101900080302	26,391	3,496/13%	2- Functioning at Risk
Eastman Creek-Owl Creek/ 101900080303	23,599	6,313/27%	2- Functioning at Risk
Lower Geary Creek/ 101900090306	17,396	8,504/49%	2- Functioning at Risk
Lower Willow Creek-Little Crow Creek/ 101900090308	17,605	7,882/45%	2- Functioning at Risk
Wildhorse Creek/ 101900090401	14,963	2,801/19%	2- Functioning at Risk
Headwaters Coal Creek/ 101900090402	28,076	11,692/42%	2- Functioning at Risk
Howard Creek-Crow Creek/ 101900090501	25,367	9,864/38%	2- Functioning at Risk
Sand Creek/ 101900090502	32,147	15,332/48%	1-Functioning Properly
EAST SIDE			
Twomile Creek/ 101900120801	35,195	4,018/11%	2-Functioning at Risk
Headwaters Cedar Creek/ 101900120803	25,810	1,666/6%	1-Functioning Properly
Headwaters Wild	28,399	8,636/30%	1-Functioning Properly

Horse Creek/ 101900140202			
101900140203	40,487	13,202/33%	1-Functioning Properly
Outlet Wild Horse Creek/ 101900140204	14,234	4,671/33%	2-Functioning at Risk
Upper South Pawnee Creek/ 101900140205	16,676	3,026/18%	2- Functioning at Risk
Middle South Pawnee Creek/ 101900140206	25,413	10,359/41%	2- Functioning at Risk

Figure 18 HUC6 watersheds representing 60% of FS lands on the PNG



The Forest Service portions of the watersheds have been rated with the National Watershed Condition Class (WCC) rating system (USDA-FS, 2011). The WCC system is a national forest-based, reconnaissance level evaluation of watershed condition based on a core set of national watershed condition indicators. The system relies on professional judgment exercised by forest interdisciplinary (ID) teams, GIS data, and national databases to the extent they are available, and on written rule sets and criteria for indicators that describe the three watershed condition classes: functioning properly (Class 1), functioning at risk (Class 2), and impaired function (Class 3). Private lands are not rated, but they are generally more highly developed than National Forest System (NFS) or National Park lands (i.e. residential and commercial developments, and agricultural use). The Forest Service has considerably less information on specific land use and watershed conditions for private lands than on adjacent Forest Service lands. The WCC system consists of 12 watershed condition indicators: Water Quality, Water Quantity, Aquatic Habitat, Aquatic Biota, Riparian/Wetland Vegetation, Roads and Trails, Soils, Fire Regime or Wildfire, Forest Cover, Rangeland Vegetation, Terrestrial Invasive Species, and Forest Health. Each of the 12 indicators is given a rating, which is then averaged into the overall WS rating. Watersheds on the PNG all fall into either Class 1 or 2.

Climate and Hydrology

Temperature and moisture are significant variables that influence soil fertility. For vegetative growth on the PNG, available moisture is the most limiting factor. Historical data shows a trend of increased temperature (1941-2005) and precipitation (1931-2005) in Colorado over time. The entire grassland area experienced a severe drought in 2002, especially when considering precipitation patterns over the last century. For New Raymer, it has taken eight years to reach the 15 inches per year average that it held from 1970 to 2000 (CSU Climate Center 2010).

The area has greatest monthly precipitation inputs during May through August (NCDC, 2010; Sala and Laurenworth, 1982). Storms are typically of short duration and high in intensity (Sala and Laurenworth, 1982). Precipitation events during these months can be intermittent showers with heavy runoff (SGS-LTER, 2010). High temperatures create a water deficit on the PNG because potential evapotranspiration (PET) is high, ranging from 2 to 10 times more than annual precipitation rates (Sala et al. 1992).

Runoff on the PNG does occur, but usually under specific circumstances. Some drainages connect to larger systems but some of them drain into playas or topographic low spots. The years that actual water is observed in intermittent streams is very sporadic and occurs infrequently. Flow in the intermittent streams on the PNG tends to be sporadic and infrequent.

During heavy rains, erodible soils (especially where bare and exposed) are scoured from drainages, resulting in bank widening, gullies and rills. Erosion and sedimentation can be exacerbated by human caused changes to the watersheds. For example, the Natural Resource Conservation Service (NRCS) suggests that changes in vegetation from native to invasive plants can decrease infiltration rates (USDA-NRCS, 2003). Roads, trampling

and other removal of vegetative cover have also been shown to influence watershed characteristics and runoff potential.

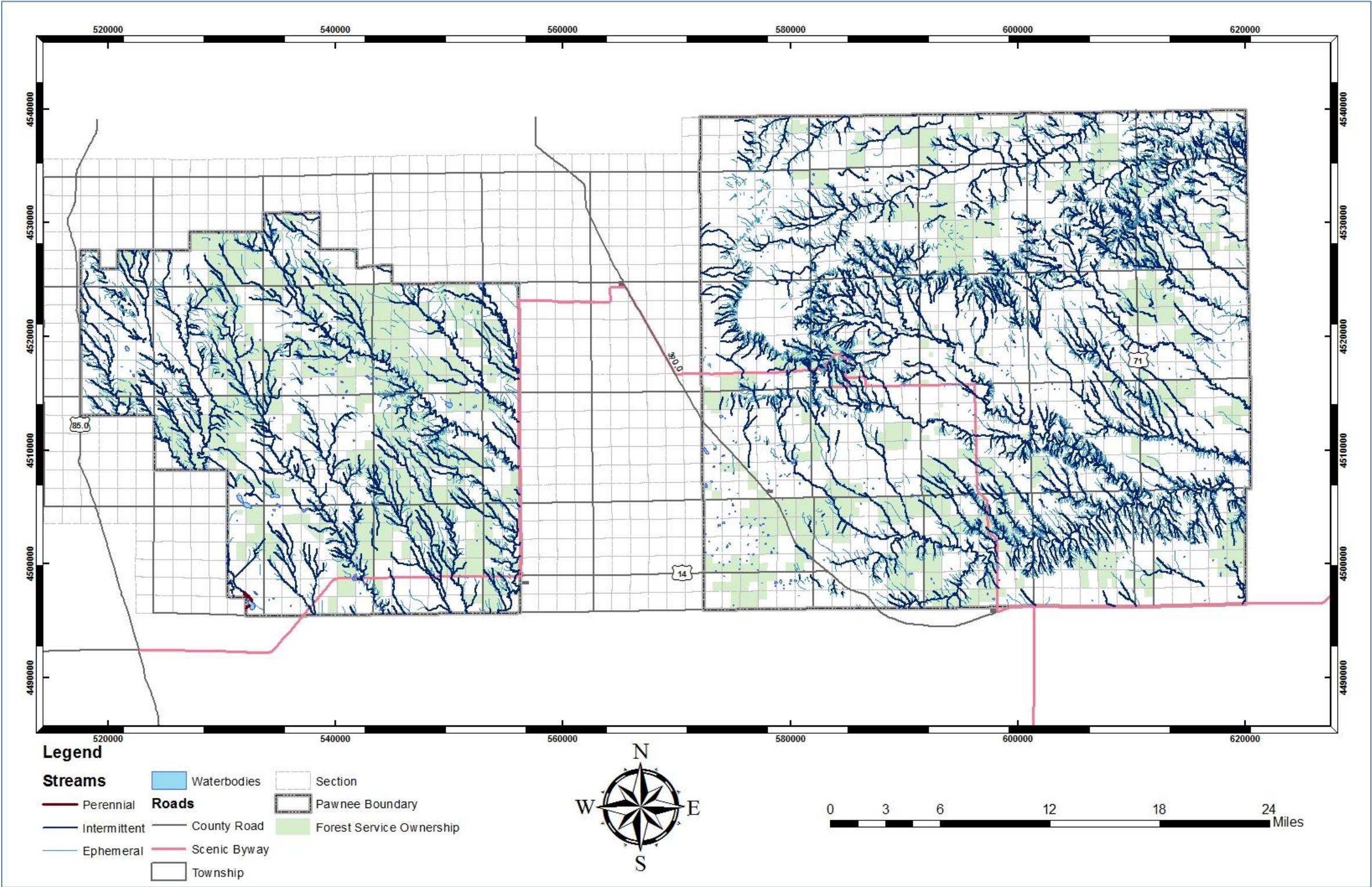
Streams, lakes, and other water sources

Sources of water, which are limited on the PNG, include streams, potholes, playas, and subsurface groundwater. The general orientation of stream drainages is northwest to southeast. On the grassland there are approximately 1,600 miles of ephemeral channels, 1,800 miles of intermittent channels, and less than 2 miles of perennial streams (Figure 7). Potholes are also a source of perennial water on the PNG. They are found in stream channels and are fed from ground water or resupplied during spring runoff, with most being permanently wet. There are approximately 33 miles of stream on Forest Service lands within PNG boundary that are suitable fish habitat, which includes perennial streams as well as some intermittent streams that have perennial pockets of water. Twelve of the 33 miles are confirmed to be occupied by fish.

The Colorado Department of Public Health and Environment (CDPHE, 2012) classifies streams, tributaries and open bodies of water on the PNG as Aquatic Life Warm 2, Recreation (E, U, N), water supply, and agriculture. Currently, no streams on the PNG are listed on the State 303d list (CDPHE, 2012) and are presumed to be meeting standards for their uses.

Playas are another important water source on the PNG. Playas are shallow clay-lined depressions on the landscape fed exclusively by precipitation events and overland flow or runoff from surrounding lands (PLJV, 2007). The high clay content in playas helps to impound water on the surface, although not throughout the entire year. During dry periods, it is not uncommon for as much as 50% of a playa bed to be without vegetation or water. Playas existing on FS managed lands are gaining more recognition as ecologically valuable because of the unique habitats they provide for various forms of terrestrial wildlife and aquatic species, and for their contribution to recharging the groundwater aquifer through cracks that form in the soil during dry periods.

Figure 19 Streams, lakes, and other water sources on the PNG



Wetlands, Riparian and Prairie Potholes areas

Wetlands and deep-water habitats are essential ecosystems. Wetlands protect water quality by trapping sediments and retaining excess nutrients and other pollutants such as heavy metals. These functions are especially important when a wetland is connected to groundwater or surface water sources (such as rivers and lakes) that are in turn used by humans for drinking, swimming, fishing, or other activities. Wetlands connected to groundwater systems or aquifers are important areas for groundwater exchange. They retain water which provides time for infiltration to occur. Groundwater, in turn, provides water for drinking, irrigation, and maintenance of streamflow and lake and reservoir levels.

Known wetlands on the PNG were overlaid with the U.S. Fish and Wildlife Service National Wetlands Inventory (NWI) database (USFWS, 2014) (Figure 8). Wetland digital data from Pawnee National Grassland were downloaded from the NWI online wetlands mapper, transferred to a Geographic Information System project and manually digitized after aerial photography verification from two different seasons (two 2013 NAIP (National Agriculture Imagery Program) images).

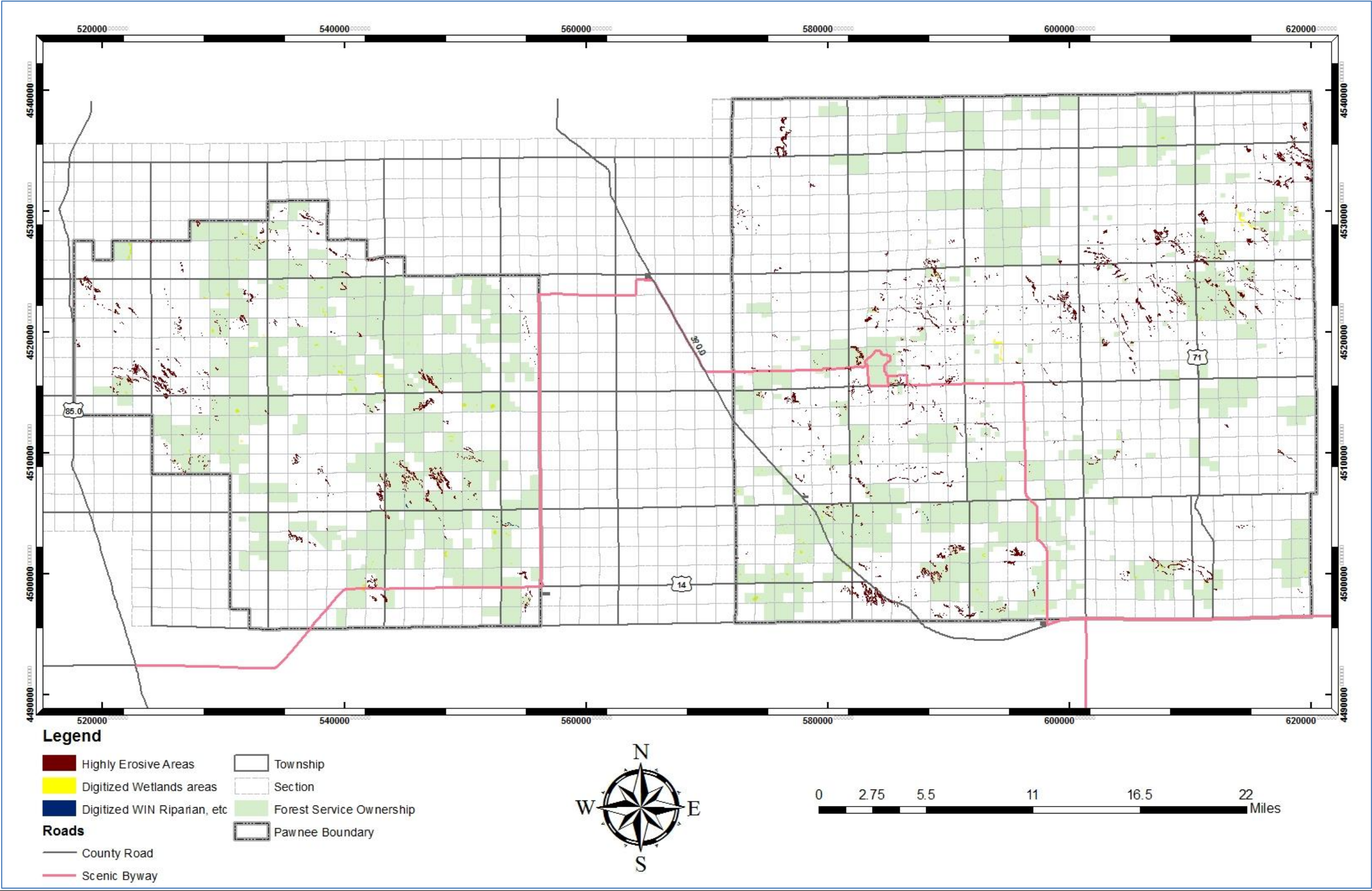
The National Wetland Inventory (NWI) from the US Fish and Wildlife classified wetlands on PNG lands (USFWS, 2014) as part of the palustrine or riverine system (Cowardin et al., 1979). The palustrine system groups the vegetated wetlands traditionally called by such names as marsh, swamp, bog, fen, and prairie, which are found throughout the United States (USFWS, 2014). The riverine system includes all wetlands and deepwater habitats contained within a channel, dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens.

There are 677 acres of mapped wetlands on Forest Service lands, including one reservoir, the Bringleston Reservoir (9 acres on the East side) (Figure 8). Most of these wetlands on Forest Service lands are classified by the National Wetland Inventory as Palustrine Emergent Wetlands some are artificially flooded or intermittently flooded. Less than 15 percent of wetlands on Forest Service lands are classified as riverine streambed intermittent/lower perennial wetlands/deepwater habitats.

Riparian zones are important natural biofilters, protecting aquatic environments from excessive sedimentation, polluted surface runoff and erosion, and are instrumental in water quality improvement for both surface runoff and water flowing into streams through subsurface or groundwater flow.

Riparian areas and prairie potholes were manually digitized from the PNG Watershed Inventory Network database (WIN). The WIN database displays geographically coordinated points surveyed on the Forest Service lands of the Pawnee National Grassland during 2008 and 2009. The feature boundaries were manually digitized using the WIN survey and two 2013 aerial photography images. Based on the Watershed Inventory database there are 11 acres of riparian areas on Forest Service land and 48 acres of prairie potholes systems (Figure 8).

Figure 20 Highly erosive areas, mapped wetland, riparian and pothole areas on the PNG

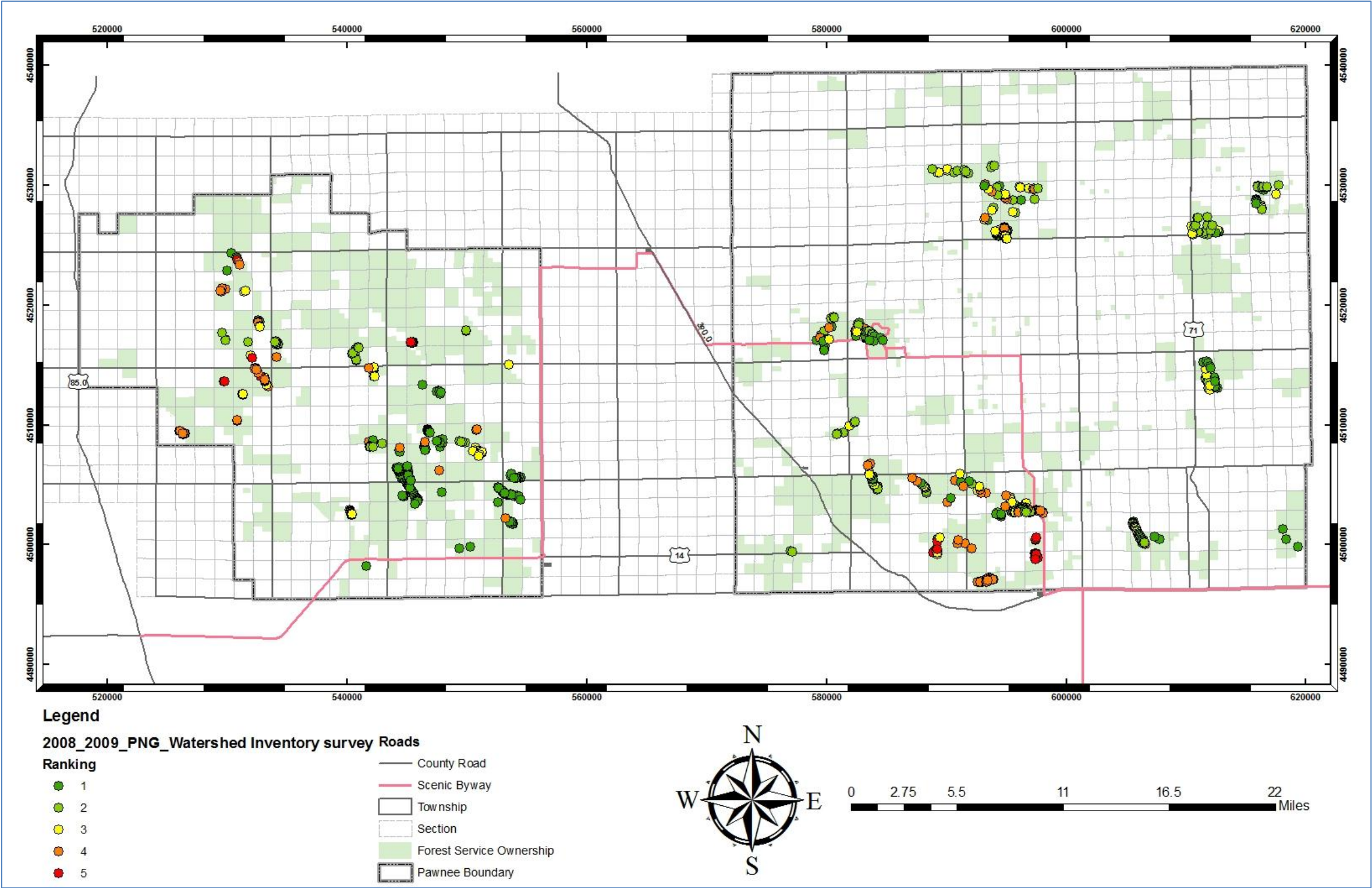


Existing watershed condition

Across the PNG, erosion features such as large gullies, road washouts, and unstable stream banks are threats to soil, water and other natural resources. Many of these features are caused or accelerated by activities such as road use, grazing, recreation and other uses. During the 2008 and 2009 field seasons, a total of 124 sites on the PNG were surveyed as part of the Watershed Improvement Needs (WIN) inventory (Figure 9). Using the WIN data, the watershed inventory sites were ranked according to (1) level of alteration, (2) need for immediate attention, (3) threat to water or other resources, and (4) feasibility of restoration and/or corrective action. The ranking exercise was followed-up with field visits to all of the highest risk sites to develop plans for remediation. Two projects have been completed to date. The WIN data provides a good overview of the areas of the PNG that have erosional or other problems, but it also contains valuable information on the location of many of the water and riparian areas across many of the drainages and watersheds.

The WIN field inventory highlighted that problem areas and their contributing watershed areas are much smaller than the entire HUC6 watershed area. However, it has been noted that the contributing area of the smaller sub-watersheds seem to experience the same magnitude of damaging effects that can be observed in the larger watershed under the proportional precipitation events of that watershed. This is referred to as “microtopography” (USDA-NRCS 2003). Thus, even at even smaller scales; erosion is initiated by channeling of overland flow and can be significant. So even though FS lands may only be a small portion of a given watershed, localized erosional areas and restoration efforts can still be significant.

Figure 21 Watershed Improvement Need Inventory sites on the PNG



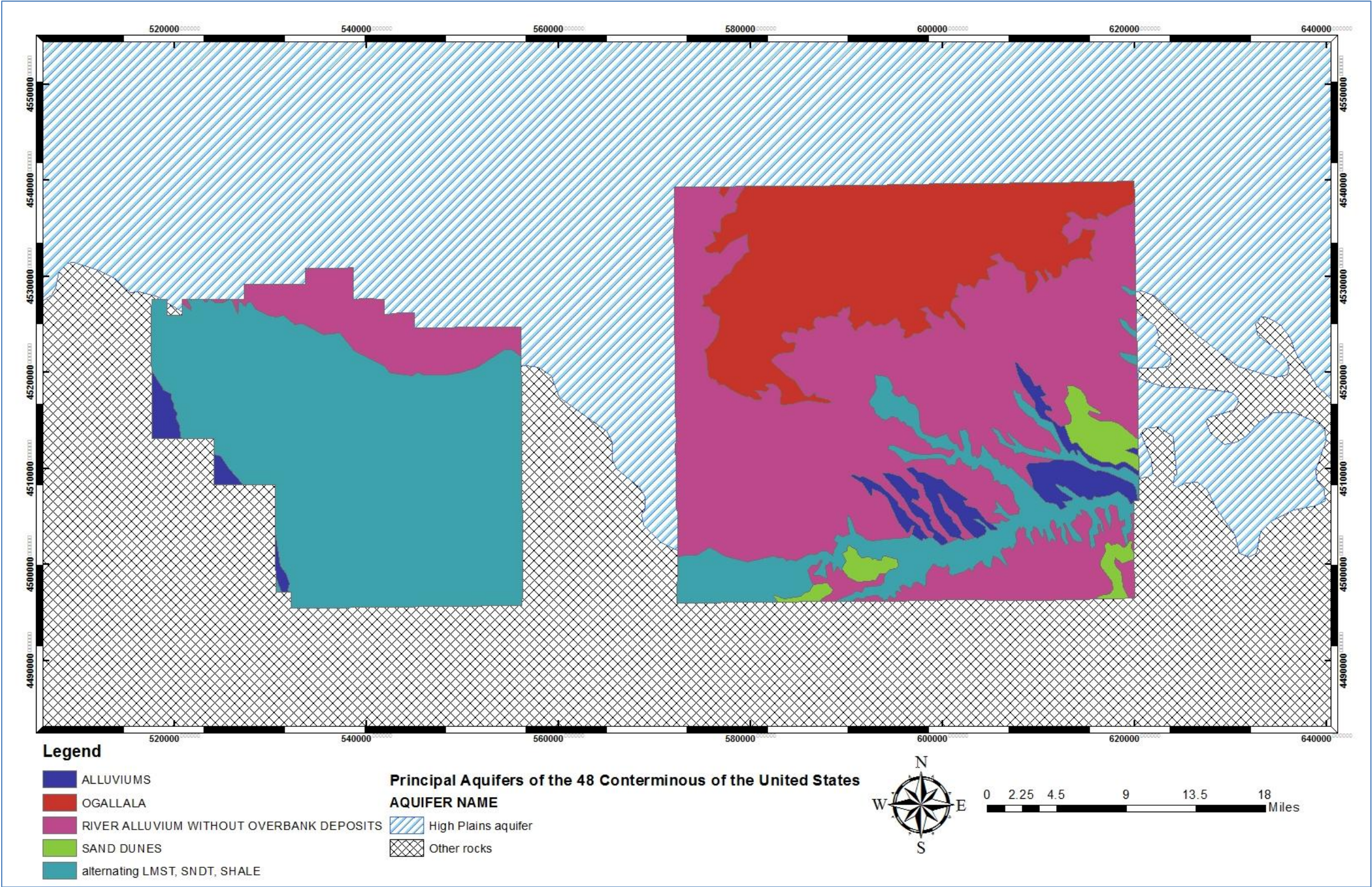
Groundwater

Based on the 2003 USGS Principal Aquifers of the 48 Conterminous United States, Hawaii, Puerto Rico, and the U.S. Virgin Islands map layer, Pawnee National Grasslands is enclosed on the Northeast by the High Plain Aquifer (58 percent), and on the southeast, western and southwest (42 percent) by rocks that are generally poorly permeable but locally may contain productive aquifers. The area is known as the High Plain Groundwater region (Heath, 1984) distributed in five hydrogeological settings. The hydrogeological settings are Ogallala, Alluviums, Sand Dunes, River Alluvium without over bank deposits and alternating Limestone, Sandstone, Shale (Aller et al., 1987) (Table 16, Figure 10).

Table 20 Hydrogeological settings and Geology of the PNG

Hydrogeological Settings	Geological Formations
ALLUVIUMS	Qgo - Quaternary Alluvium - Slocum Alluvium
Alternating LMST, SNTD, SHALE	Kl -Laramie Formation / Kf - Fox Hills Sandstone / Kpu - Pierre Shale
OGALLALA	To - Ogallala Formation
RIVER ALLUVIUM WITHOUT OVERBANK DEPOSITS	Tw - White River Group - (Brule/Chadron Formations)
SAND DUNES	Qe - Eolian and Loess Deposits

Figure 22 Hydrogeological Settings on the PNG



The High Plains region is underlain by one of the most productive and most intensively developed aquifers in the United States. This is alluvial materials derived from the Rocky Mountains, which are referred to as the Ogallala Formation (Boettcher, 1966). Younger eolian sand and alluvial deposits overlay the Ogallala Formation, and where these deposits are saturated, they form part of the High Plains aquifer. The White River Group (Chadron/Brule Formation) underlies the Ogallala formation and forms the base of the High Plains aquifer. Locally productive aquifers (confined aquifers) are found on the lower medium and fine grained sandstone sections of the Laramie and Fox Hill formations.

The saturated thickness of the High Plains aquifer ranges from less than 1 foot to more than 1,000 feet and averages about 200 feet. It varies geographically and is thickest in the northern High Plains (Wyoming Water Development Commission, 2008). Water and chemical movement to the water table are controlled, in part, by the thickness and composition of sediments in the unsaturated zone. The Eolian sands deposits yield small supplies of water locally but are important recharge areas. The permeability in alluvium deposits is high in gravels and low in clay/silt layers. The Ogallala is a regional aquifer with small to large yields and good water quality. The White River is a regional aquifer with small to large yields and good water quality in some areas. The lower Laramie Formations section yields small quantities of water to domestic and stock wells but the water quality is generally poor. The lower Fox Hills Sandstone shows a medium permeability which yields moderate quantities of water to domestic, stock and municipal wells.

The Colorado Division of Water Resources wells map layer shows that the water table depth on Pawnee National Grassland ranges from 0 to 465 feet on the west side and 5 to 1,188 feet on the east side (CDWR, 2014).

The technical report “Grassland Climatology of the Pawnee Grassland” shows average annual precipitation as 11 to 13 in/year for the West section and 13 to 15 in/year for the East section (Rasmussen et al, 1971). Precipitation ranges increase in both sections in a southeastern direction. Recharge rates of about 0.07 in/yr are common in much of the area, but could increase as much as 0.8 to 1.0 inch of water per year (Wyoming Water Development Commission, 2008). Recharge to the High Plains Aquifer occurs by infiltration of irrigation water, aerially diffuse infiltration from precipitation, focused infiltration of storm and irrigation water runoff through streambeds and other topographic depressions, and upward movement of water from underlying aquifers. Due to the fact that so much of the streamflow in the region is diverted for irrigation, the only source of groundwater recharge now is local precipitation.

Discharge from the High Plains aquifer occurs primarily by irrigation well pumping, discharge to streams and underlying aquifers, groundwater flow across the eastern boundary of the aquifer, and evapotranspiration.

Based on the CDSS’ (Colorado Decision Support System) (CDWR, 2014) decreed wells map layer, exempt groundwater wells are the primary water sources on the East and West

Pawnee Grassland sections for a total of 160 exempt groundwater wells on Forest Service land (Mathesen and Bowden, 2011). Exempt groundwater wells are classified by the Colorado Division of Water Resources as wells that are exempt from water rights administration and are not administered under the priority system. In most cases, exempt well permits limit the pumping rate to no more than fifteen gallons per minute. Exempt groundwater wells are Household Use Only Wells, Domestic and Livestock Wells, etc.

The United States Environmental Protection Agency, defines an underground sources of drinking water (USDWs) as an aquifer or a portion of an aquifer that 1) supplies any public water system; 2) Contains sufficient quantity of groundwater to supply a public water system; and i) currently supplies drinking water for human consumption; or ii) contains fewer than 10,000 milligrams per liter (mg/L) total dissolved solids (TDS); or iii) is not an exempted aquifer. USDWs on the PNG were not mapped for the EIS analysis, but a site specific assessment of local USDWs will be needed during the APD stage of development.

EPA works with state and tribal agencies, non-governmental agencies and citizen groups to encourage partnerships and provide information for carrying out source water protection actions (EPA, 2013). Source water is untreated water from streams, rivers, lakes or underground aquifers that is used to provide public drinking water, as well to supply private wells used for human consumption. The Source water protection actions begin with a source water assessment, one of the assessment components is the delineation of source water protection areas (SWPA). SPWA are portion of a watershed or ground water area that may contribute pollution to the water supply. EPA delineated 4 generalized source water protection areas near Pawnee National Grassland (Figure 6). The first protection area (T8N R62W Section 20 NE1/4) comprises some Forest Service lands while the other protection areas are outside but adjacent to PNG FS land.

According to the CDSS' (Colorado Decision Support System) (CDWR, 2014), there are approximately 259 domestic, 15 household use only and 9 municipal wells permits issue on private lands within the Pawnee National Grassland administrative boundary (Figure 7).

In January 2013, the Colorado Oil and Gas Conservation Commission (COGCC) approved the statewide groundwater and monitoring rules. The rules 609 and 318A.e became effective May 1, 2013. The purpose of these rules is to gather baseline water quality data prior to oil and gas development and after drilling and completion operations (COGA, 2013 and COGCC, 1999 and 2012).

- Rule 609 requires oil and gas operators to sample all available water sources, (up to four), within one half mile radius of a proposed Oil and Gas well, multi- well sites, and dedicated injection wells for which a form 2 application for permit to drill is submitted on or after May 1, 2013. Under this rule operator shall select sampling location based in a criteria of preferred water sources such as proximity (closest to proposed well), type of water source (preferable well maintained domestic water wells), orientation of sampling locations, multiple identified aquifers available and condition of water source.

- Rule 318A.e requires that baseline samples and subsequent monitoring samples shall be collected from one available water source in the governmental quarter section in which a new Oil and Gas well, the first well on a multi-well site or a dedicated injection well is located. Sampling location is based in the same criteria as rule 609.
- Rule 318A(I) - *Greater Wattenberg area special well location, Spacing and unit designation rule*. The Greater Wattenberg Area ("GWA") is defined (section a) to include those lands from and including Townships 2 South to 7 North and Ranges 61 West to 69 West, 6th P.M. Under this rule water sampling will be performed pursuant to rule 609.

100,329 acres of unleased PNG Forest Service lands (federal and private mineral rights) would be subject to the Rule 609 and 318A.e. Leased lands acres would be subject to those rules if a permit to drill was submitted on or after May 1, 2013 and/or if existing leases expire.

Based in the Colorado Decision Support System, available water sources are located in approximately 10 % of unleased PNG Forest Service lands however, less than 1 percent of those available water sources are domestic well permits. Therefore, it is probable in some sites to not locate available water sources; neither the quantity nor to follow the sampling location criteria. In those cases operators will follow rules 609 and 318A.e regulations.

Per rule 318A(I) section a, Pawnee National Grassland is located outside from the defined Greater Wattenberg area (GWA).

Figure 23 Generalized Source Water Protection Areas Provided by the Environmental Protection Area

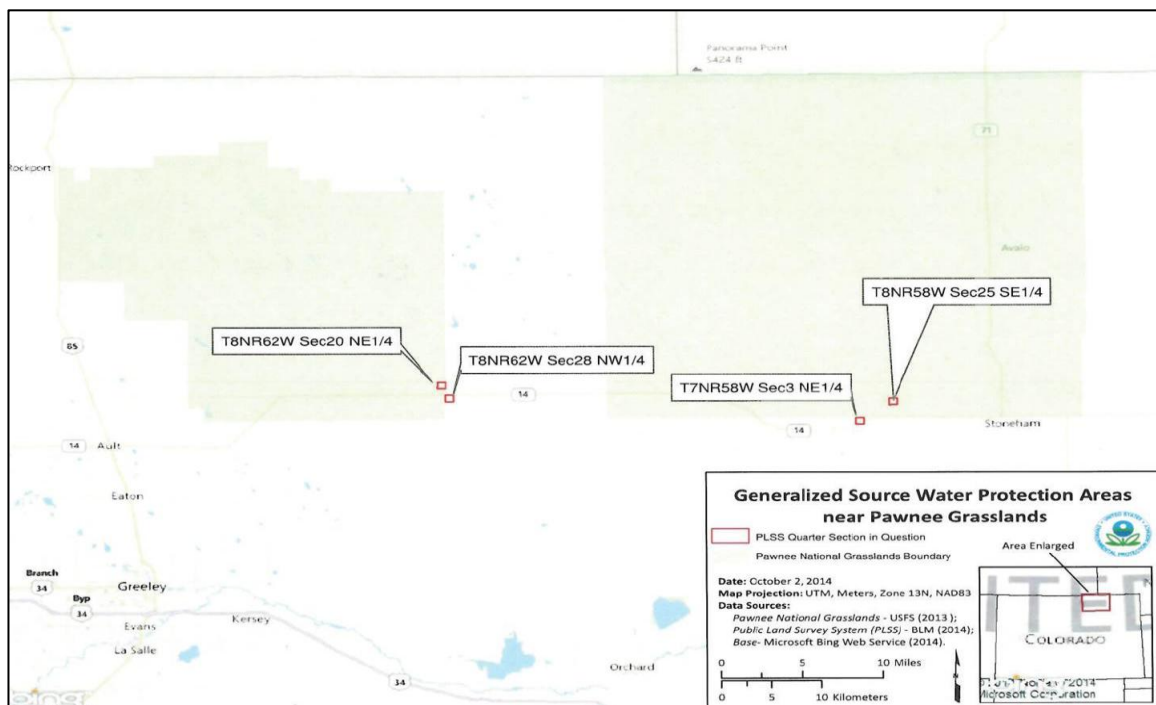
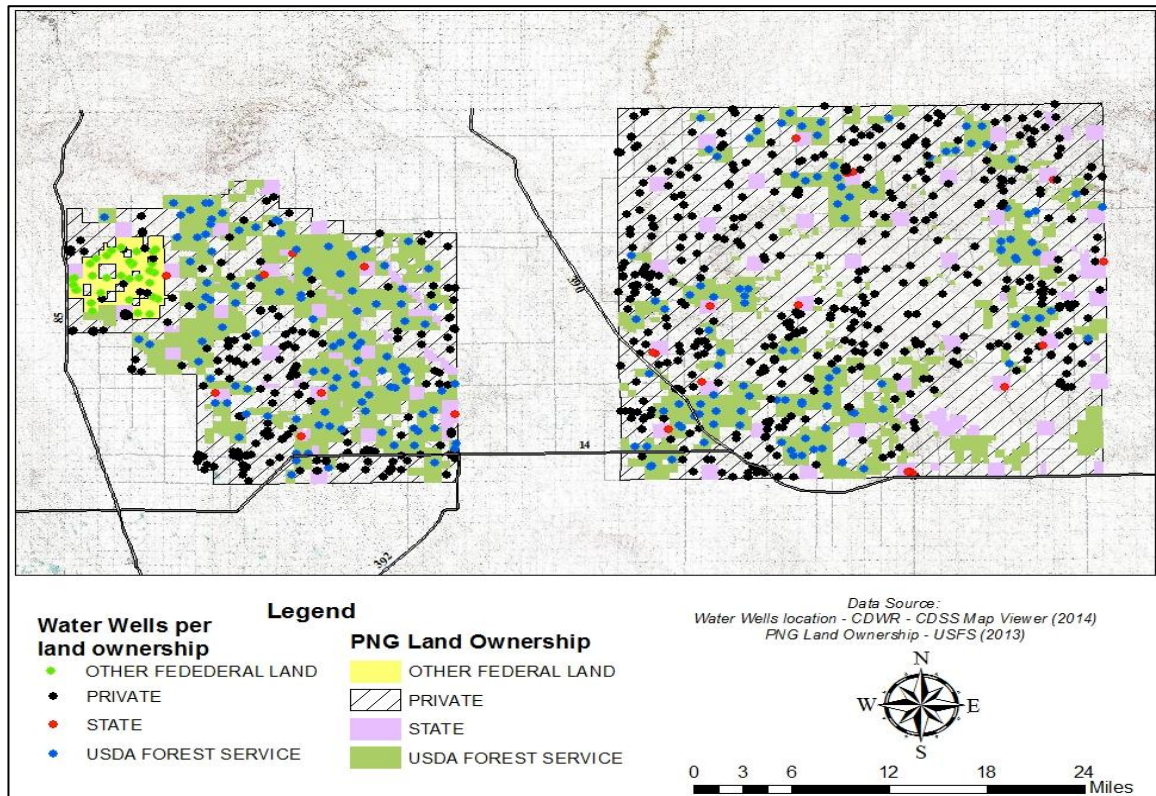


Figure 24 Pawnee National Grassland Boundary Water Well Permits located by Surface Land Ownership



Groundwater Vulnerability (DRASTIC)

Drilling and associated production could impact groundwater quality through leaks, spills, pits, poorly cemented production wellbores, pipelines, or evaporation ponds. A groundwater vulnerability conceptual model was completed following the EPA DRASTIC semi-quantitative model methodology (Aller et al., 1987). The DRASTIC index method allows a systematic evaluation of groundwater pollution potential anywhere in the United States based on designated mappable units known as hydrogeological settings. The method incorporates the major hydrogeological parameters which affect and control groundwater movement including depth to water, rate of recharge, aquifer, soil and vadose zone media, topography and hydraulic conductivity.

Preparation of the model required comprehensive evaluation of relevant ground water data from the USGS, Colorado Geological Survey, Colorado State Engineer's Office, National Resources Conservation Service, EPA, and consultant's reports for the local area (see Data Sources list). The data was used to rank all the hydrogeological parameters (depth to water, rate of recharge, aquifer, soil and vadose zone media, topography and hydraulic conductivity) using the 1987 DRASTIC manual and ranges/ratings tables (Aller et al., 1987).

For the Pawnee National Grassland groundwater vulnerability model, each of the following hydrogeological parameters was classified from least sensitive to most sensitive (see Figure 11):

- **Depth to Water Table:** 1 to 10
- **Recharge (net annual):** 1 to 4
- **Aquifer media:** 1 to 7
- **Soil media:** 1 to 10
- **Topography (slope):** 1 to 10
- **Impact of the vadose zone:** 3 to 8
- **Hydraulic Conductivity:** 1 to 10

Figure 25 DRASTIC parameter tables

Depth to Groundwater (feet)		Net Recharge		
Rating	Value	Land Cover	Soil Taxonomy	Values
10	0-5	Barren Land (Rock/Sand/Clay)/Cultivated Crops/Deciduous Forest/Developed, Low – medium - Open Space/Evergreen Forest/Grassland/Herbaceous/Pasture/Hay/Shrub/ Scrub	Different soil textures(see appendix XX)	1
9	5-15	Barren Land (Rock/Sand/Clay)/Cultivated Crops/Deciduous Forest/Emergent Herbaceous Wetlands/Evergreen Forest/Grassland/Herbaceous/Open Water/Pasture/Hay/Shrub/Scrub/Woody Wetlands	Different soil textures(see appendix XX)	2
7	15-30	Emergent Herbaceous Wetlands/Grassland/Herbaceous/Open Water/Pasture/Hay/Shrub/Scrub/Woody Wetlands	Different soil textures(see appendix XX)	3
5	30-50	Emergent Herbaceous Wetlands/Grassland/Herbaceous/open water	Different soil textures(see appendix XX)	4
3	50-75			
2	75-100			
1	100+			

Soil Media		Topography (Slope)	
Texture	Values	Slope Percent (%)	Values
clayey	1	>20	1
badland; clay loam/ clay; clayey over sandy or sandy-skeletal	2	15 - 20	3
fine-loamy; silty and clayey soils	3	10 --15	5
fine-loamy over sandy or sandy-skeletal; fine-silty; fine sandy loam/ clay loam/ clay; fine sandy loam/clay loam; loam/ clay/ clay loam; loam/clay/ silty clay loam	4	5 --10	8
loamy	5	0-5	10
gravelly sand / loamy sand some clay loam; loam, gravelly loam, sandy loam	6		
coarse loamy; playas	7		
sandy; sandy skeletal	9		
water	10		

Aquifer Media	
Geologic Formations	Value
Pierre Shale (Kpu)	1
Laramie Formation (Kl)	3
White River Group (Twr)	3
Fox Hills Sandstone (Kf)	4
Ogallala Formation (To)	4
Eolian Deposits (Qe)	5
Quaternary Alluvium (Qgo)	7

Vadose Zone	
Geologic Formations	Values
Pierre Shale (Kpu)	3
Laramie Formation (Kl)	5
White River Group(Twr)	5
Fox Hills Sandstone (Kf)	6
Ogallala Formation (To)	6
Eolian Deposits (Qe)	6
Quaternary Alluvium (Qgo)	8

Hydraulic Conductivity	
Geologic Formations	Values
Pierre Shale (Kpu)	1
Laramie Formation (Kl)	2
White River Group(Twr)	2
Fox Hills Sandstone (Kf)	2
Ogallala Formation (To)	6
Eolian Deposits (Qe)	4
Quaternary Alluvium (Qgo)	10

The 7 parameter ratings were then overlaid and weighted using a Geographic Information System to calculate indices for each hydrogeological setting across the PNG. These results suggest that on the Pawnee National Grassland, groundwater resources are more vulnerable to adverse effects (pollutant contamination) in areas where:

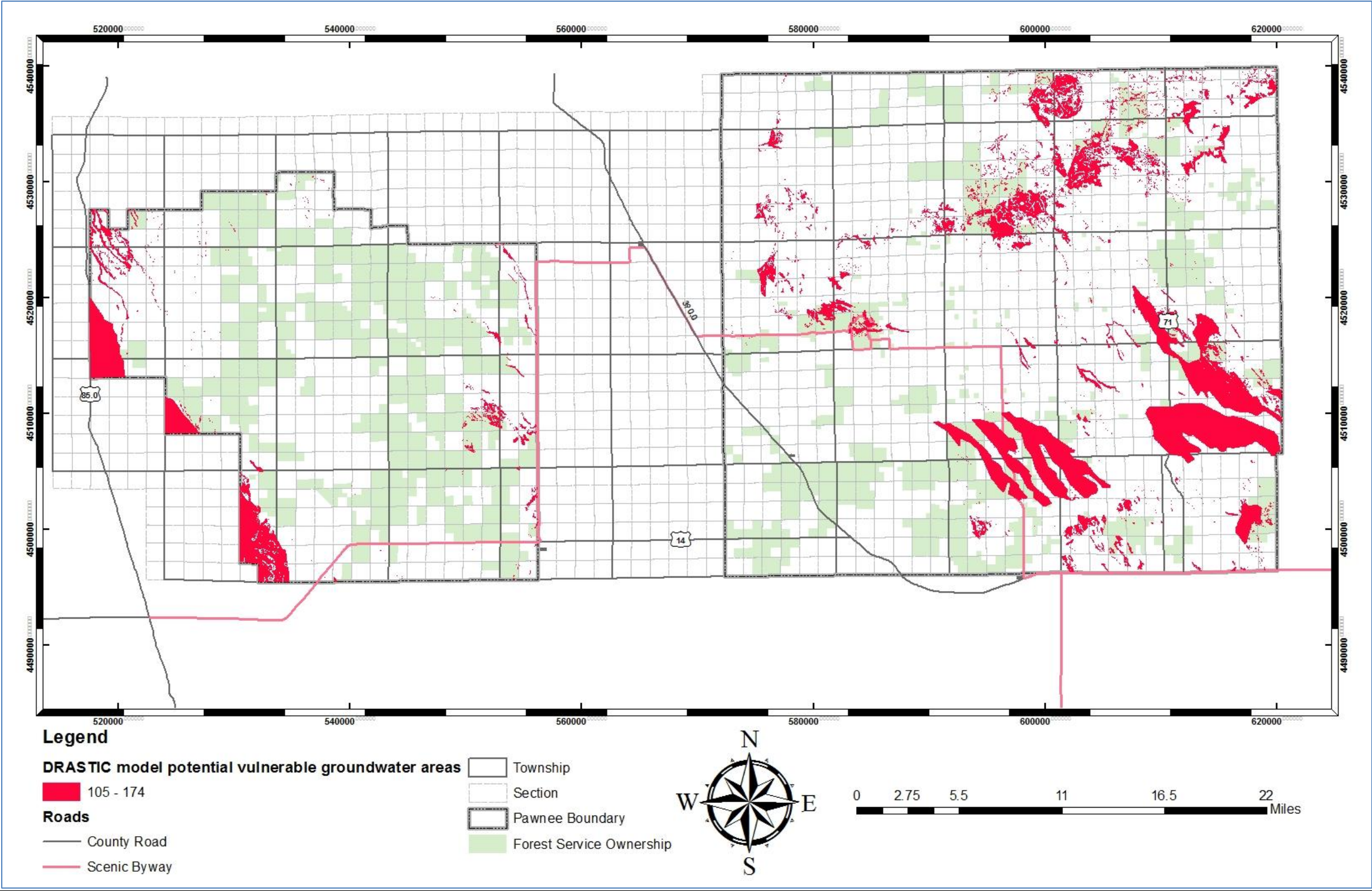
- Depth to ground water is 0 - 30 feet from surface.
- Recharge areas with vegetation cover (land cover) such as grasslands, croplands, different wetlands, and open water section overlay on medium to coarse grained soils.
- The aquifer media is comprised of quaternary alluvium formations that consist of gravel, sand, silt and clay alluvial sediments.
- The soil media overlying the uppermost water bearing unit consists of sand, sandy skeletal, coarse – loamy textures or over playas.
- The area is relatively flat and infiltration and media transportation rates are high.
- The Vadose zone (intermediate zone between the soil surface and the water table) material consists of unconsolidated deposits of gravel and alluvium material (sand).
- The dominant geology material is sand and gravel with hydraulic conductivity ranging from 200 up to 4,000 GPD/ft².

In general, the model results provide a map of the geographical areas where ground water would be more vulnerable to contamination from surface occupancy based on the DRASTIC numerical rating (Figure 11). Areas where these conditions are most likely to occur inside the PNG Boundary have DRASTIC Indices from 105 to 174. Within the PNG administrative boundary, a total of 63,258 acres fall into this range. On NFS lands only, 10,705 acres (5 percent) of PNG lands fall into this range, mostly on the east side. 2 percent of those areas are already impacted under existing leases or under private mineral rights.

High groundwater vulnerability indexes overlay mostly on Alluviums, Ogallala, and Sand Dunes hydrogeological settings; with some exposed areas on the Alternating Limestone, Sandstone and Shale settings which correspond to Fox Hills Sandstone Formations.

69 percent of the areas with high groundwater vulnerability are located on lands with moderate-high to high conventional Oil and Gas development potential, based on the Bureau of Land Management Reasonable Foreseeable Development report. This represents a range of 10 to 20 wells per township in the moderate-high category and 20 to 50 wells per township in the high category. Under these developments there is a high risk of shallow groundwater contamination, directly from well injection if the well is not constructed properly, surface spills, etc.

Figure 26 DRASTIC model results: Areas of the PNG with high groundwater vulnerability



Soil Resources

Pawnee National Grassland soil resources existing conditions were evaluated using the Natural Resources Conservation Service's (NRCS) Weld County soil survey (CO 617). The Soil survey data was downloaded January 24, 2013 from the NRCS-Geospatial Data Gateway. Additional soil information was gathered from the NRCS-Web Soil Survey website and the NRCS-Soil Data Mart website on January 24, 2013 and January 26, 2013 (NRCS, 2013a&b).

There are 73 soil series on the PNG. Loamy soils are the dominant textural classification, with 99 percent classified as fine sandy loam. PNG soils originated mainly from sedimentary deposits. The sedimentary deposits are classified in seven formations; Fox Hill Sandstone, Laramie Formation, Pierre Shale-Upper unit, Eolian deposits, Older gravels and alluviums, Ogallala Formation, and White River Formation or Group. The dominant rock types in these formations are sandstone (49%), shale (46%), dune sand (3%), and gravel (2%). The sedimentary rock erosion originated soils through alluvium (73%), colluviums (5%), eolian (0.4%) and residuum (21%) depositions. Alluvium deposits cover 73% of the PNG acres. Alluvium deposits are unconsolidated water eroded material. This implies that over the long-term (decades to centuries), water erosion action occurred in the area.

Soils Physical Properties

- Under dry conditions, PNG soils are dominantly well drained soils. Excessively drained soils occur over 3% of the area.
- Infiltration is the downward entry of water into the soil (NRCS, 2008). Approximately 63% of the soils on the PNG exhibit a moderate to high infiltration rate. This is due to the high sandy and moderate loam material with alluvium origin. Low to very low infiltration rates occur on 36% of the PNG acres; this condition is related to wet, clayey soils, areas suited to water storage. Some of the areas with moderate infiltration rates occur under clayey soils with a sandy subsurface
- Overall, soils within the Pawnee National Grassland exhibit a moderate rutting potential. This rating indicates that rutting is likely.
- Only 5% of the PNG soils show high plasticity levels corresponding to wet soil areas and high clay surface textures. A high Plasticity level indicates a high rutting potential and the likelihood that ruts form readily.
- Under current conditions, soils within the project area have not reached the minimum bulk density values at which root-restricting conditions may occur. This suggests that in the present soils within PNG do not exhibit compaction features. However, most of the soils do not exhibit ideal bulk densities for plant growth, which indicates that they have a prompt susceptibility to formation of compaction layers.

Soil runoff and erosion potential

- Most of the PNG soils show a low to medium surface runoff potential. This indicates that, depending on the slope, climate and vegetation cover, most of the

-
- PNG soils have a high to moderate infiltration rate due to porosity and low slope surface (i.e. plains).
- Erosion factors within the PNG soils indicate a moderate susceptibility to sheet and rill erosion. This is due to the high sand content, low organic matter and low percentage of rock fragment.
 - Wind erosion potential is measured using the NRCS soil survey wind erodibility group (WEG). Around 81 percent of PNG soils are considered susceptible (high to moderate) to wind erosion, with a WEG ranging from 2 to 4.

Soil engineering properties

- For the PNG, the NRCS rates 52% of the soil series as somewhat limited to local road construction. This indicates that excavation, grading and traffic movement on these soils could be limited due to frost action, shrink swell potential, slope, depth to soft bedrock, and low strength.
- Approximately 80% of the PNG soils are rated as somewhat limited to shallow excavations. A somewhat limited rating indicates that the soil has features that are moderately favorable for the specified use. This rating is given to soils that have one or more limiting factors for digging in the area and results in a higher probability that excavations could collapse. The limitations can be overcome or minimized by special planning, design, or installation. The rest of the PNG soils are rated as very limited to shallow excavations. A very limited rating indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Soil Reclamation potential and/or nutrient cycle behavior

- Soil organic matter within PNG soils is rated “dominantly low” (0.75 to 1.5%). This rating indicates that the soil surface, upon disturbance, would be more prone to crusting, erosion, and depleted nutrient levels.
- According to the NRCS reclamation rating, approximately 78% of the soils on the PNG are rated as “fair” for reclamation potential. This means that vegetation can be established and maintained and the soil can be stabilized through the modification of one or more properties.
- The rest of the PNG soils (22%) have a poor reclamation potential. This means that re-vegetation and stabilization would be very difficult and costly. Depending on the physical and topographic properties of the soil, erosion, and runoff issues could occur.

Soil Surface water restrictions

- Eleven acres of the soils on the PNG are classified as aquic moisture regime. These wet soils have a saturated area up to 72 inches deep and include partially hydric soil. These soils are located on channel, stream terraces, swales, and floodplain landforms.

- Most of the soils within the Pawnee National Grassland exhibit a moderately high to high saturated hydraulic conductivity at the surface (zero depth). This rating indicates that PNG soils under saturation conditions exhibit a high risk of subsurface contaminant transport.
- This high saturated hydraulic conductivity prevails up to 15 inches in depth. Therefore, after a heavy rain system saturated soil layers could exist at 0 to 15 inches into the soil profile, with a high risk of contaminant transport.

3.7.2 Environmental Consequences

Methodology

Soil and Hydrology Resource Components

1. Areas where surface water and groundwater resources are susceptible to degradation
 - a. Indicators: acres available for development with high risk to critical watersheds and groundwater resources.
2. Areas with soils that have high erosion potential and are near streams, lakes, springs, wetlands, floodplains, and riparian areas (including riparian veg).
 - a. Indicators: acres available for development with high erosion potential or near to water resources.

Surface Water

Forest Service ownership is less than 50% in the majority of watersheds on the PNG, so the ability of the FS to affect changes at the watershed scale is limited. Areas where concentrations of resource components are located will be more likely to be adversely affected by oil and gas activities. HUC6 watersheds where concentrations are higher are listed in the table below. Acres that may be developed are displayed by alternative for each watershed.

Table 21 Acres open to surface disturbance by alternative and HUC6 watershed (Forest Service land)

HUC 6 WS name/#	Primary concerns	WS size (acres)	Acres (%) existing leases- Federal and private minerals	Acres open to surface disturbance Alt 1	Acres (%) open to surface disturbance Alt 2	Acres open to surface disturbance Alt 3
WEST SIDE						
Little Owl Creek/ 101900080302	Perennial Pools w/ fish, erosion	26,391	2,118 (8%)	0	1,380 (5%)	0

Eastman Creek-Owl Creek/ 101900080303	Perennial Pools w/ fish, erosion	23,599	3,799 (16%)	0	2,508 (11%)	0
Lower Geary Creek/ 101900090306	Perennial Pools w/ fish, erosion	17,396	2,772 (16%)	0	5,726 (33%)	0
Lower Willow Creek-Little Crow Creek/ 101900090308	Perennial Pools w/ fish, erosion, large exclosure	17,605	4,291 (24%)	0	3,585 (20%)	0
Wildhorse Creek/ 101900090401	Perennial Pools w/ fish, erosion, shooting impacts	14,963	1,607 (11%)	0	1,192 (8%)	0
Headwaters Coal Creek/ 101900090402	Perennial Pools w/ fish, erosion	28,076	5,861 (21%)	0	5,822 (21%)	0
Howard Creek-Crow Creek/ 101900090501	Perennial Pools w/ fish, erosion	25,367	5,366 (21%)	0	4,069 (16%)	0
Sand Creek/ 101900090502	Perennial Pools w/ fish, erosion	32,147	4,804 (15%)	0	10,488 (33%)	0
	TOTAL		30,618	0	34,770	0
EAST SIDE						
Twomile Creek/ 101900120801	Perennial Pools w/ fish	35,195	89 (0%)	0	3,928 (11%)	0
Headwaters Cedar Creek/ 101900120803	Perennial Pools, caves, riparian areas	25,810	0 (0%)	0	1,665 (6%)	0
Headwaters Wild Horse Creek/ 101900140202	Perennial Pools w/ fish, erosion	28,399	6,893 (24%)	0	1,436 (5%)	0
101900140203	Perennial Pools w/ fish	40,487	10,018 (25%)	0	3,175 (8%)	0
Outlet Wild Horse	Perennial	14,234	4,253	0	415	0

Creek/ 101900140204	Pools w/ fish, erosion		(30%)		(3%)	
Upper South Pawnee Creek/ 101900140205	Perennial Pools w/ fish	16,676	2,249 (13%)	0	775 (5%)	0
Middle South Pawnee Creek/ 101900140206	Perennial Pools w/ fish	25,413	7,767 (31%)	0	2,907 (11%)	0
	TOTAL		31,269	0	14,301	0

Effects to surface water on the PNG will be possible in areas with: surface disturbance, road and pipeline crossings, leaks/spills, pits or evaporation ponds. Shallow groundwater is also included in the surface water analysis, as shallow groundwater is thought to be a primary source of water for the surface water features on the PNG.

Direct/Indirect Effects

Effects common to all alternatives:

Effects of traffic, water use, disposal of produced water and used fracking fluids, and accidents/spills are occurring across the project area, both on NFS lands and on private lands.

Spills in the State of Colorado are well documented and occur frequently ([Center for Western Priorities](#), 2014). The Center has posted online a “[Colorado Toxic Release Tracker](#)” using available data compiled by the Colorado Oil and Gas Conservation Commission. According to the data, there were 495 oil industry-related chemical spills in Colorado in 2013, and nearly a quarter of the spills impacted ground or surface water. Impacts from the fall 2013 flooding in Colorado heavily damaged oil and gas facilities in the South Platte River floodplain. There were 56 spills reported in January 2014, 3 of which impacted groundwater and 1 that impacted surface water. 33 of the spills occurred within 1,000 feet of surface water, 14 spills occurred within 500 feet of surface water, 11 spills occurred less than 50 feet from groundwater, and 7 spills occurred between 50 and 100 feet from groundwater. Based on the Center for Western Priorities interactive map, there were 61 spills (94,164 gallons) reported from 2006-2014 in the general PNG area.

Alternative 1: No New Leasing:

There wouldn't be any additional surface disturbance or impacts to surface water resources on the PNG from the no leasing alternative. There could be residual effects to water resources in that drill pads and wells could be placed directly on the borders of NFS lands. The placement of these facilities would not be subject to the same restrictions as those on NFS lands and could cause greater impacts in those areas than they would on NFS lands.

Alternative 2: No Action, leasing under current Forest Plan:

Under Alternative 2, all of the watersheds with high value water resources would have some level of surface disturbance; Sand Creek on the West side and Two Mile Creek on

the East side are the watersheds that would have the most activity and disturbance. Under the current Forest Plan, water resources are primarily protected by the Standard Leasing Terms (SLT) which allows the FS to require facilities be moved up to 200 meters to avoid impacts. However, oil and gas operations in upland areas that drain to perennial surface waters and fisheries resources could still put these resources at risk from sediment or chemical contamination even outside of the 200 meter “buffer”. These contaminants could be transported from the watershed as surface water or as shallow groundwater.

One watershed with critical water resources, Little Owl Creek, has a portion protected by a NSO stipulation as part of the Owl RNA. This would help to protect the important water features and aquatic biota present in the perennial pools in that drainage. Other critical watershed resources would not have the same protection under this alternative.

Alternative 3: Leasing under NSO:

No drill pads or wells would occur on NFS lands. There could be residual effects to water resources in that drill pads and wells could be placed directly on the borders of NFS lands. The placement of these facilities would not be subject to the same restrictions as those on NFS lands and could cause greater impacts in those areas than they would on NFS lands. An APD with potential Conditions of Approval would still be required.

Cumulative Effects:

Across the HUC6 watersheds, regardless of ownership, effects from the action alternatives would be cumulative to effects from previously leased and developed areas. Impacts from development of existing leases as well as private mineral leases would continue. Watersheds that have development within 200m of surface water resources would continue to have impacts. In addition, oil and gas operations in upland areas that drain to perennial surface waters and fisheries resources, would put these resources at risk from sediment or chemical contamination. These contaminants could be transported from the watershed as surface water or as shallow groundwater. Furthermore, effects from leasing occurring on private lands would be cumulative to effects from NFS lands at the watershed scale. It is likely however, that the effects of activities on NFS lands would be minor and unmeasurable at the watershed scale under Alternatives 1 and 3, but could increase under Alternative 2.

Water Use and Management Associated with Leasing and Production

Significant quantities of water are required for drilling and hydraulic fracturing operations. If water wells or surface water resources are used for this, significant impacts to PNG water resources could occur, including water table depletion and loss of surface water recharge areas. In addition, large quantities of flowback and produced water need to be dealt with at the well sites. Storage and transport of these large quantities of non-potable water also has risks to water quality on the PNG. The Colorado Division of Water Resources is responsible for permitting and administering water rights in the State, and any water developments or uses from or on NFS lands would need to be completed following appropriate procedures.

Approximately 22,100 to 39,500 acre-feet (AF) of water is used for fracking annually in Colorado (Western Resource Advocates, 2012). Typically, water for drilling and fracking in Weld County has been supplied from non-tributary groundwater wells and municipal water from surrounding cities. After drilling, the produced water is primarily disposed of in deep injection wells, making it unavailable to the water cycle. Some of the produced water is also being reused or recycled in the area.

The associated traffic is also significant to the area, especially with the increased risk for spills into water resources. Traffic is greatly increased to bring and remove this water from drilling sites. A recent report completed for Douglas County, CO estimates 11,040 loaded truck trips for one well pad (containing six wells) over a 265 day period (6,000 trips were made to haul fracking water and 3,000 trips were for wastewater disposal). The Bureau of Land Management report estimates 1,160 truck visits are required to develop each well.

Direct/Indirect effects:

It takes approximately 2 acre-feet (AF) of water to drill one well. In the Niobrara Formation (Northern Colorado, Chesapeake Energy), it takes approximately 4 million gallons (12.28 AF) to hydraulically fracture one well (Western Resource Advocates, 2012). For this analysis, it is assumed that each well will need to be fractured 4 times over the life of the well³².

Alternative 1: No new leasing:

No new wells will be developed, so no additional water would be needed on the PNG, but the same amount of water would still be needed as Alternative 2, if the same number of wells is needed on private lands. If there are 10% more wells needed without leasing PNG minerals, then 10% more water would be needed to drill the wells.

Alternative 2: No action, leasing under current Forest Plan:

Greater quantities of water would be needed than under the no new leasing alternative (approximately 7,140 AF would be needed for 140 wells)³³.

Alternative 3: Leasing under NSO:

If wells are simply moved off NFS lands, the same amount of water would still be needed as Alternative 2, if the same number of wells would be needed on private lands.

³² Formula: water usage for one well = 2AF (drilling – one time) + (12.28AF * 4 “fracking usage”) = 51.12AF.

³³ 140 wells is an estimated value based in an area proportion of federal mineral rights available for leased within PNG (53%). This value will be additional water usage to current leased lands and represent the direct effect of water usage under 100% federal mineral right within FS surface lands.

Cumulative Effects:

The water needed under the new leases would be cumulative to the water needed for the already leased lands and leasing on private mineral estate, which is approximately another 6,400 AF³⁴.

Groundwater Vulnerability

Drilling and associated production could impact groundwater quality through leaks, spills, pits, poorly cemented production wellbores, pipelines, or evaporation ponds. Accidental spills anywhere could cause isolated introduction of pollutants into near-surface ground water sources which could be of local significance depending on location, season and size of spill. In addition, the State of Colorado prohibits oil and gas operations within 500 feet of any permitted water wells.

Direct and Indirect Effects:

Alternative 1: No new leasing:

Under this alternative, 6,786 acres of the PNG that have a high groundwater vulnerability rating within the unleased available acres will be protected from direct contamination and surface disturbance. These areas will be available for groundwater recharge, which would help to increase the shallow groundwater resources in the area and decrease any surface and subsurface contamination.

Alternative 2: No action, leasing under current Forest Plan:

Under Alternative 2, up to 6,786 acres with a high groundwater vulnerability rating within the available unleased acres would be at risk from hazardous chemical spills which frequently occur from Oil and Gas activities. Substances such as hydraulic fluid, fracking fluids, and produced water could leak from evaporation pits and /or injection wells and could be transported laterally and vertically to the shallow groundwater resources and to surface water bodies. Reduction of recharge potential at developed sites would also be likely in these areas, due to the loss of soil infiltration features such as organic matter.

Increased groundwater consumption for drilling activities may also result in water table depletion. Drilling close to alluvial aquifers could impact recharge areas such as potholes, ponds, wetlands and riparian areas. There would also be a greater risk of lateral shallow groundwater pollution from leasing in sensitive areas or from adjacent private lands under Oil and Gas development.

Alternative 3: Leasing under NSO:

Up to 6,786 acres with high groundwater vulnerability would be protected from risk. This alternative would result in the lowest amount of groundwater acres impacted due to Oil

³⁴ 6,400AF represent the estimated water usage within FS surface ownership but with private mineral rights and leased lands. Adding this acres to the available for lease FS lands with federal mineral rights the total water usage is: 6,400 AF + 7140 AF = 13,540 AF OR 51.12 AF * 265 wells = 13546 AF.

and Gas activities. This would result in less risk to surface water quality, a reduction in the amount of sedimentation potential, and an increase in groundwater recharge, which would increase shallow groundwater resources.

Table 22 Acres of potential disturbance or protection to vulnerable groundwater resources

	Alternative 1	Alternative 2	Alternative 3
Disturbed acres	0	6,786	0
Protected acres	6,786	0	6,786

Cumulative effects:

The cumulative effects analysis boundary for groundwater is the NFS lands on the PNG.

Under Alternatives 1 and 3, higher concentrations of well structures and facilities could occur on adjacent private surface and mineral ownership. The amount of well concentration depends on the level of development on site and the economic feasibility of Oil and Gas reservoirs on non-leasable and NSO areas. This would be cumulative to development on the 3,458 acres on existing leased and private mineral right acres on Forest Service jurisdiction.

The effects to groundwater under Alternative 2 would be cumulative to the effects from the existing leases as well as the private leases across the Grassland. Up to 10,244 acres with high groundwater vulnerability may be affected, (2,515 acres on existing leased lands, 943 acres within private mineral rights and 6,786 acres on the available leasable federal mineral rights, not including 461 acres of “No lease by decision” from the 1997 Forest Plan). These areas with high groundwater vulnerability represent over 1.3 percent (2,515 acres) of the existing leased areas, mostly on the east side.

Within these areas with high groundwater vulnerability, there is higher potential for groundwater contamination. In addition, lateral groundwater contamination could occur from adjacent private jurisdiction which is currently leased and/or available. Clustering of well structures could occur on private lands adjacent to areas with high groundwater vulnerability. Groundwater recharge will be reduced due to a decrease in ideal infiltration from disturbed surface areas. There could also be a reduction in groundwater discharge (water table depletion) to surface water flows if the main water source for Oil and Gas activities comes from the area groundwater.

Soils

Impacts from oil and gas activities in the following areas could be detrimental to soil resources and water resources.

- A. Areas with high sediment contribution potential within stream buffers and loss in soil productivity (compaction, rutting, wind erosion, poor reclamation potential).
- B. Wetlands, Riparian and Pothole areas

Areas with high sediment contribution potential within stream buffers and loss in soil productivity

Most of the soils on the PNG have a moderate susceptibility to sheet and rill erosion (erosion due to water forces). However, due to the high sand content, low organic matter, low percentage of rock fragment and topography, under continuous surface disturbance these areas become highly susceptible to surface erosion.

In addition, soils with high surface runoff potential can develop preferential flow sections. Preferential flow is the uneven and often rapid movement of water and solutes through the soil by cracks, root holes, and fractures on the soil surfaces. It allows much faster transport of contaminants to the vadose zone and groundwater sources, and increases the occurrences of gullies and loose sediment areas that could contribute sediment and contaminants to playas, wetlands, potholes and/or ponds.

Mapped areas with highly erosive soils and soils with high surface runoff potential were overlaid and related geographically to the stream layer in GIS. This process located areas equal or less than 200 meters away from streams, which could be sources of sediment contribution from developed areas. There are 1,510 acres with high potential for sediment contribution within the PNG. Additional disturbance activities in these areas could result in bare soil and loose surfaces escalating the in situ erosion potential and sediment transportation (including chemical contaminants) to streams, wetlands, potholes, ponds, and other water sources.

There are 740 acres with low soil productivity across the PNG. These areas need additional soil amendments and/or best management practices to reduce any erosion or runoff potential and increase soil productivity during disturbance activities such as well pads, pipeline trenching, road construction, etc. Without management practices revegetation and stabilization would be very difficult and costly in these areas.

Approximately 81 percent of PNG soils are considered moderately to highly susceptible to wind erosion, with a WEG (Wind Erodibility Group) ranging from 2 to 4. Soils with a WEG of 2 to 4 are typically susceptible to 85-140 tons/ac/yr of sediment loss. Due to the potential effect to air quality and reduction in soil productivity, disturbance of these soils could be detrimental to the PNG.

Direct and Indirect Effects

Alternative 1: No new leasing:

All of the areas with high sediment contribution potential which are located on current available leasable lands will be avoided. This represents a total of 838 acres, which is 55% of all the areas with high erosion and sediment contribution potential across the PNG. Not leasing these areas would have benefits to water quality, soil productivity and shallow groundwater resources. All of the areas with poor reclamation potential would not be disturbed (450 acres – 62 %), decreasing the likelihood of bare soils, wind erosion and low soil productivity on PNG lands.

Alternative 2: No action, leasing under current Forest Plan:

The areas with high sediment contribution potential which are located on current available leasable lands (a total of 838 acres, which is 55% of all the areas with high erosion and sediment contribution potential within the PNG) could be disturbed under this alternative. Up to 61% of the low productivity soils could be disturbed, which could reduce the reclamation potential of the area (450 acres).

Most of these areas could transport sediment and pollutant to surface water bodies (streams) within a 200 meter buffer; also increasing the pollutants transportation through the soil profile. There could also be direct impacts to aquatic habitat and wildlife survival, shallow groundwater resources quality and quantity, and surface water quality.

81 percent of the PNG has soils with high wind erosion potential and approximately 21 percent of the PNG is in soils with high rutting potential. Soil productivity will be highly reduced in these areas due to mechanical disturbance, no erosion control, or revegetation growth practices.

Alternative 3: Leasing under NSO:

Under NSO, more than 838 acres (55%) of the areas of high erosion potential across the PNG will be protected. Surface disturbance and sediment contribution to surface water bodies from leasing activities would be minimal. Erosion features such as gullies, cracks, and any other degradation will be minimal, which would help reduce the likelihood of rapid transport of water and solutes through the soil profile. Soil productivity and ground cover will improve in these areas (61% of the sensitive soils), consequently preventing any additional sedimentation to surface water, which would help for maintaining water quality in nearby water resources. Good ground cover and soil productivity will result in a higher organic soil cover and the deposition of colloidal particles which are suitable to retaining some of the inorganic pollutants used in oil and gas operations, subsequently helping to prevent shallow groundwater contamination.

Table 23 Acres with high sediment contribution potential disturbed or protected, by alternative

<u>Alternatives</u>	<u>Disturbed acres</u>	<u>Protected acres</u>
No New Leasing – Alt 1	0	838
No Action, leasing under current Forest Plan - Alt 2	838	0
Leasing under NSO - Alt 3	0	838

Table 24 Acres of potential soil productivity changes due to surface disturbance or protection, by alternative

<u>Alternatives</u>	<u>Disturbed acres</u>	<u>Protected acres</u>
No New Leasing – Alt 1	0	450
No Action, leasing under current Forest Plan - Alt 2	450	0

Leasing under NSO - Alt 3	0	450
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Cumulative Effects:

The cumulative effects analysis boundary for soil resources is the NFS lands on the PNG.

Alternative 1: No new leasing and Alternative 3: Leasing under NSO:

- a) A total of 647 acres (43%) of areas with high sediment contribution potential will continue to be disturbed due to existing development of leased FS lands and lands with private mineral rights with FS surface.
- b) There is no monitoring information that classifies the current erosion and/or surface cover conditions of these areas, as well as the possible affected surface water bodies.
- c) Some watershed reclamation and erosion control projects might be required in these areas to reduce sediment contribution to surface water, to increase soil productivity up to Forest Service guidelines, and to be in compliance with water quality standards.

Alternative 2: No action, leasing under current Forest Plan:

- a) A total of 1,485 acres (98%) of highly erosive areas could be disturbed (currently leased, private mineral rights on FS surface and available leasable lands)
- b) Additional surface disturbance (on Forest Service land and private) could occur from other management projects and other adjacent Oil and Gas facilities such as pipelines and access roads.
- c) Adjacent disturbance (from private surface developments) could promote degradation to the mentioned sensitive areas; this will depend on the level of use (traffic), footprint disturbance (i.e. excavation failure), etc.
- d) There could be a detrimental loss in soil productivity on almost 100 percent of highly sensitive soils (high erosion and low productivity soils) under available, existing leases and private mineral rights.
- e) 80 percent of the areas with existing leases are in areas of high susceptibility to wind erosion and 21 percent are in areas with poor reclamation potential. Monitoring of these areas is needed to classify the erosion, and soil productivity levels and any needed surface management restrictions.

Wetlands, Riparian and Potholes areas

Altering the hydrology of wetland and riparian areas will result in restricting inflow and outflow of the surface water and groundwater (reduction of discharge and recharge potential); reducing residence time of water (less filtration), and introducing toxic substances.

53 percent of wetland areas occur on available leasable lands, the rest are located on currently leased lands. There are 48 acres of mapped prairie potholes systems on PNG, with half of it on current leased lands.

Direct and Indirect Effects

Alternative 1: No new leasing:

All wetlands, riparian and potholes areas on available leasable lands (362 acres) will be protected. Protecting these areas will promote groundwater recharge, sediment runoff filtration, removal of toxic substances adjacent to sensitive areas, wildlife habitat and an increase in water surface discharge (shallow water quantity).

Alternative 2: No action, leasing under current Forest Plan:

Up to half of the wetlands, riparian and potholes acres on FS lands could be impacted by development. As stated in the 1997 Forest Management Plan, development could occur under Standard Leasing Terms (SLTs), which provide the ability to move facilities up to 200m. This would provide the FS the ability to protect wetlands smaller than 400 m². Operators would also be liable to the US Fish and Wildlife, EPA and/or ARMY Corps under these agency wetland protection regulations (Clean Water Act). Disturbance adjacent to wetlands or riparian areas could promote sediment and toxic substance transportation and storage on these areas, which could destroy vegetation cover and/or affect these surface water ecosystems. Site specific wetland delineation would occur prior to development.

Alternative 3: Leasing under NSO:

All wetlands, riparian and potholes areas on available leasable lands (362 acres) will be protected. Protection of these areas will promote groundwater recharge, sediment runoff filtration, removal of toxic substances adjacent to sensitive areas, wildlife habitat, and an increase in water surface discharge (shallow water quantity).

- a. Operators could use horizontal drilling to move underground across wetland, riparian, reservoir and potholes areas (for other secondary oil and gas structures such as pipelines). This process could result in underground pollution and interference with the inflow and outflow of surface or groundwater resources.

Table 25 Acres of mapped wetland, riparian and potholes disturbance and protection per alternative

<u>Alternatives</u>	<u>Disturbed acres</u>	<u>Protected acres</u>
No New Leasing - Alt1	0	362
No Action, leasing under current Forest Plan - Alt 2	362	0
Leasing under NSO - Alt 3	0	362

Cumulative Effects:

The cumulative effects analysis boundary for wetland and surface water resources is the NFS lands on the PNG.

1. No new leasing / No action: leasing under current Forest Plan:

-
- a. Up to 677 acres of wetlands, riparian, and potholes could be disturbed. The level of protection from the Forest Service on these sensitive areas depends on the mineral rights jurisdiction. Higher protection will be available on 363 acres (available leasable lands), some protection will occur on 103 acres (existing leased) as stated in the 1997 Forest Management Plan, under which development would occur under SLTs, which provide the ability to move facilities up to 200m. Lower protection will occur on 211 acres (private mineral rights).
 - b. Some of these areas might have been disturbed due to existing well developments, resulting in a loss of wetland, riparian areas consequently losing groundwater recharge zones and water filtration areas.
 - c. If these recharge areas are disturbed there could be an additional negative impact to the groundwater and surface water quantity and quality on Forest Service lands due to diminished infiltration.

Summary of Effects

In summary, for soil and water resources, Alternative 2 would have the highest risk to soil and water resources (Table 22). Alternative 3 has the least risk, followed by Alternative 1, which has a slightly higher risk due to the likelihood for 10% more wells surrounding the PNG than would be needed under Alternatives 1 and 2.

Table 26 Summary of effects

Resource Component	Oil and Gas Development Impacts	All Alternatives	Alternative 1	Alternative 2	Alternative 3
		Effects on existing leases and private mineral estates	No Additional Leasing	No Action--leasing across PNG under current Forest Plan	Leasing under No Surface Occupancy
Acres available for leasing		43,444	0	146,367	146,367
New wells/well pads		some percentage of Alt 2	0/0	241/80	0/0
Acres new surface disturbance		some percentage of Alt 2	0	960	0
1. a. Areas where surface water resources are potentially susceptible to degradation	Environmental risks from erosion and sediment deposition into surface water	Development will continue to increase on leased NFS Lands and private mineral estate; Risks are present and will potentially rise for streams and other water resources.	Development will not occur on most NFS Lands; Risks will be lower to streams on NFS lands, may increase for adjacent private lands	Development will increase on most NFS Lands, between 3% and 39% of individual critical watersheds could be developed; risk will rise for water resources across the PNG. Critical watersheds with more than 20% potential development occurs only on the West side.	Development will not occur on most NFS Lands; Risks will be lower to streams on NFS lands, may increase for adjacent private lands.
	Accidental releases of hydrocarbons and industrial chemicals into surface water	Within existing leases and on private mineral estate, surface and ground water sources may become contaminated as a result of spills, discharges, or accidents.	Surface and groundwater sources supporting suitable habitats have potential to become contaminated as a result of spills, discharges, or accidents where roads or other facilities are located near to NFS lands.	Surface and groundwater sources supporting suitable habitats would be more likely to become contaminated as a result of spills, discharges, or accidents.	Surface and groundwater sources supporting suitable habitats have potential to become contaminated as a result of spills, discharges, or accidents where roads or other facilities are located near to NFS lands.
1.b. Areas where groundwater resources are potentially susceptible to degradation	Surface release of hydrocarbons or industrial chemicals could contaminate potential surface recharge areas and groundwater.	32 percent of the existing lease and private mineral estate areas, mostly on the east side, are in areas with high vulnerability for groundwater contamination.	Development will not occur on most NFS Lands; Risks will be lower to groundwater on NFS lands, but may increase on adjacent private lands.	30 percent of the PNG administrative boundary is in areas with higher risk for groundwater contamination. On available NFS lands only, 6,786 acres (5 percent) of PNG lands fall into this range, mostly on the east side. 2 percent are at the highest risk.	Development will not occur on most NFS Lands; Risks will be lower to groundwater on NFS lands, but may increase on adjacent private lands.
2. Areas with high erosion potential near streams, lakes, springs, wetlands, floodplains, and riparian areas (including riparian veg).	Unacceptable amounts of surface erosion or runoff, especially in areas with surface water.	42 percent of existing leases and private mineral estate are on highly erosive soils (high potential sediment contribution areas to streams).	Development will not occur on most NFS Lands; Risks will be lower to surface water resources on NFS lands, may increase on adjacent private lands.	There are 838 acres with high potential for sediment contribution to water resources and 450 acres with poor reclamation potential within the PNG lands available for leasing.	Development will not occur on most NFS Lands; Risks will be lower to surface water resources on NFS lands, may increase on adjacent private lands.
OVERALL RISK SUMMARY			Less than Alt 2, more than Alt 3-- due to 10% increase of wells outside FS lands due to no leasing	Highest	Least

3.8 Fisheries Resources

Fisheries and Aquatic Resource Issues

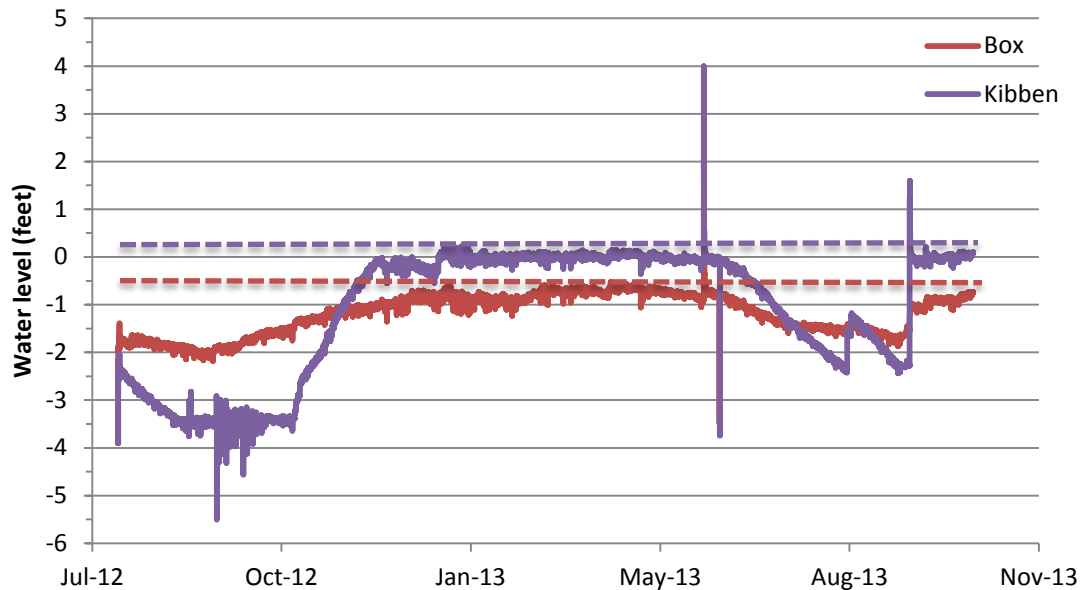
1. Suitable aquatic habitat either supporting or capable of supporting native fishes of the Pawnee National Grassland (PNG)
2. Surface and groundwater sources that supply water to sustain suitable habitats
3. Connection habitat that links patches of suitable aquatic habitat within the stream networks of the PNG
4. Risks to population persistence for plains topminnow on PNG
5. Risks to species viability for plains topminnow and plains killifish on PNG

3.8.1 Affected Environment for Fisheries

The Pawnee National Grassland contains several land parcels among 39 sixth field (i.e., 6 digit hydrologic units) prairie watersheds on a portion of Colorado's eastern plain. All of the plains streams occurring on the grassland are tributary to the South Platte River. This is a portion of the western Great Plains that extends from eastern Colorado and eastern Wyoming east across much of Nebraska, portions of South Dakota, and into Kansas. These prairie watersheds originate on the plains and have developed into a loosely parallel drainage pattern, exhibiting a hydrology characterized by flooding and drying. Resultantly, few of these streams are continuously perennial. Rather, most streams are intermittent with short sections of perennial surface water that occur as semi-connected pools along the streamcourse (Figure 13).

Surface water within these clusters of aquatic habitat is maintained by stochastic precipitation events great enough to generate overland flow during and shortly following storm events and via groundwater that is exposed to the surface where pool-like depressions occur along the streamcourse. Based on 75 years of precipitation data, the greatest amount of precipitation falls from April through June; however, some areas experience a wet monsoon season in August and September (USDA Forest Service, unpublished data). These wet periods likely generate sufficient stream flow to connect separate perennial habitats within a 10-year period or less. Although small and unseen by most, these unique aquatic habitats occur in most of the intermittent stream channels across the western Great Plains, including the Pawnee National Grassland.

Figure 27 Water level changes in perennial surface water habitats from July 2012 to October 2013 in the South Pawnee Creek drainage, Pawnee National Grassland, Weld County, Colorado. Water levels above dashed lines approximate periods when surface flow were present.



Amount and Distribution of Aquatic Habitat

Although the total amount of aquatic habitats on the Pawnee National Grasslands may be quite limited during a snapshot of time, the linear networks in which those habitats occur are large, covering multiple 40,000 acre watersheds that stretch from southeastern Wyoming to the South Platte River. Hydrologic data used to classify the types of stream channels are not very well resolved; however, based on National Hydrography Data (USGS), there are well over 3000 miles of stream channel on the Pawnee grassland with at least 30 of those miles being perennial and over 1,700 miles being intermittent (Entwistle and Nieves-Rivera 2014). The amount and distribution of aquatic habitat suitable for aquatic life varies based on annual precipitation patterns as well as the capacity of local aquifers to maintain pockets of exposed groundwater. At this time it is unclear which aquifers are most important in supplying water to the specific perennial aquatic habitats. Three key aquifers are believed to have great enough hydrostatic pressure and groundwater volume to support surface water habitats: the Ogallala, the Brule member of the White River Group, and numerous undefined shallow, perched aquifers (Wohl et al. 2009). Several artesian springs occur on the grassland and supply groundwater from the deep aquifers (i.e., Brule formation) to support some perennial aquatic habitat. A groundwater mapping model, called DRASTIC (Aller et al. 1987), was used to identify the vulnerabilities and potential susceptibilities of groundwater resources on the Pawnee National Grassland (Entwistle and Nieves-Rivera 2014). Approximated groundwater influence zones have been described in depth in the Hydrology and Soils Report (Entwistle and Nieves-Rivera 2013). Precipitation events occurring in the spring and summer seasons can recharge some of the shallow perched aquifers. While flood events are both infrequent (i.e., once every year or two) and typically of very short duration (i.e., less than 24 hours), events can be very high in magnitude, exceeding the calculable 100-year and 500-year flow rates for these small intermittent streams (USDA Forest Service unpublished data).

Table 27 . Summary of the amount and distribution of aquatic habitat

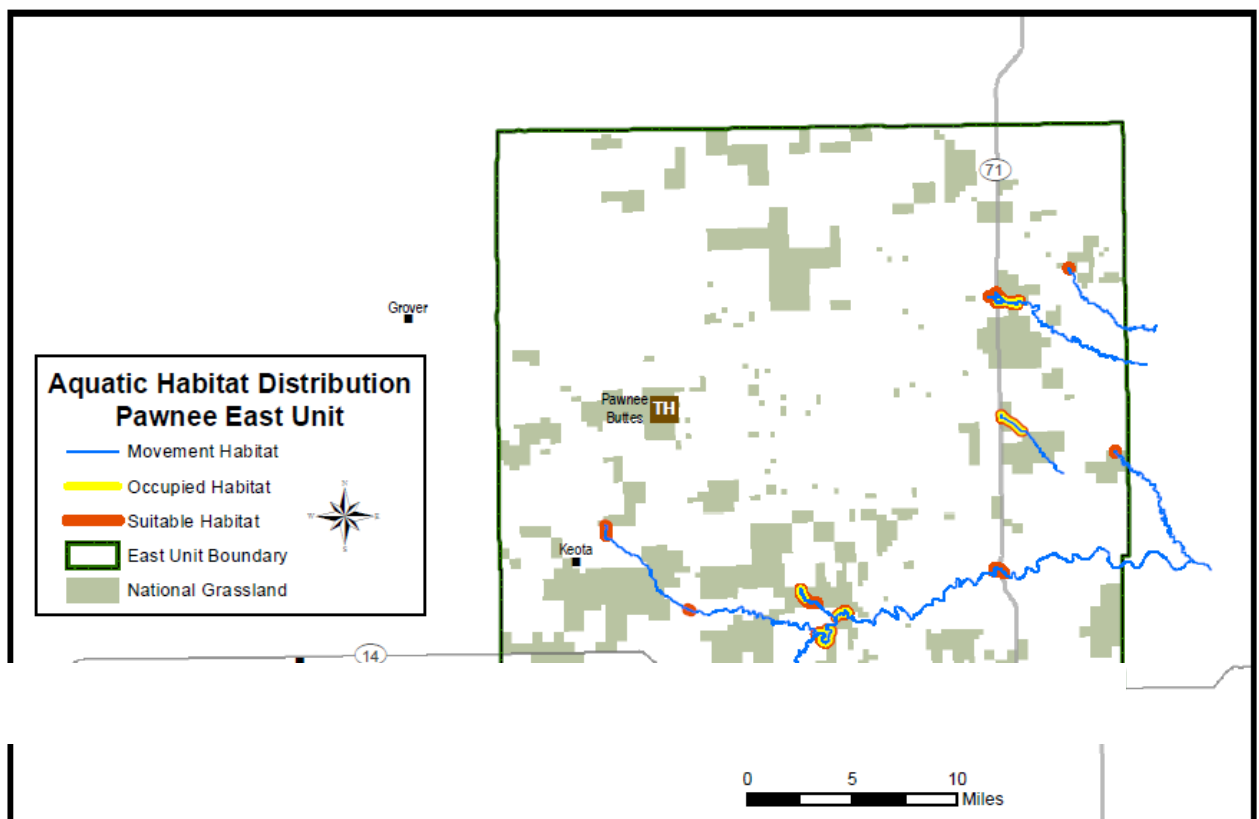
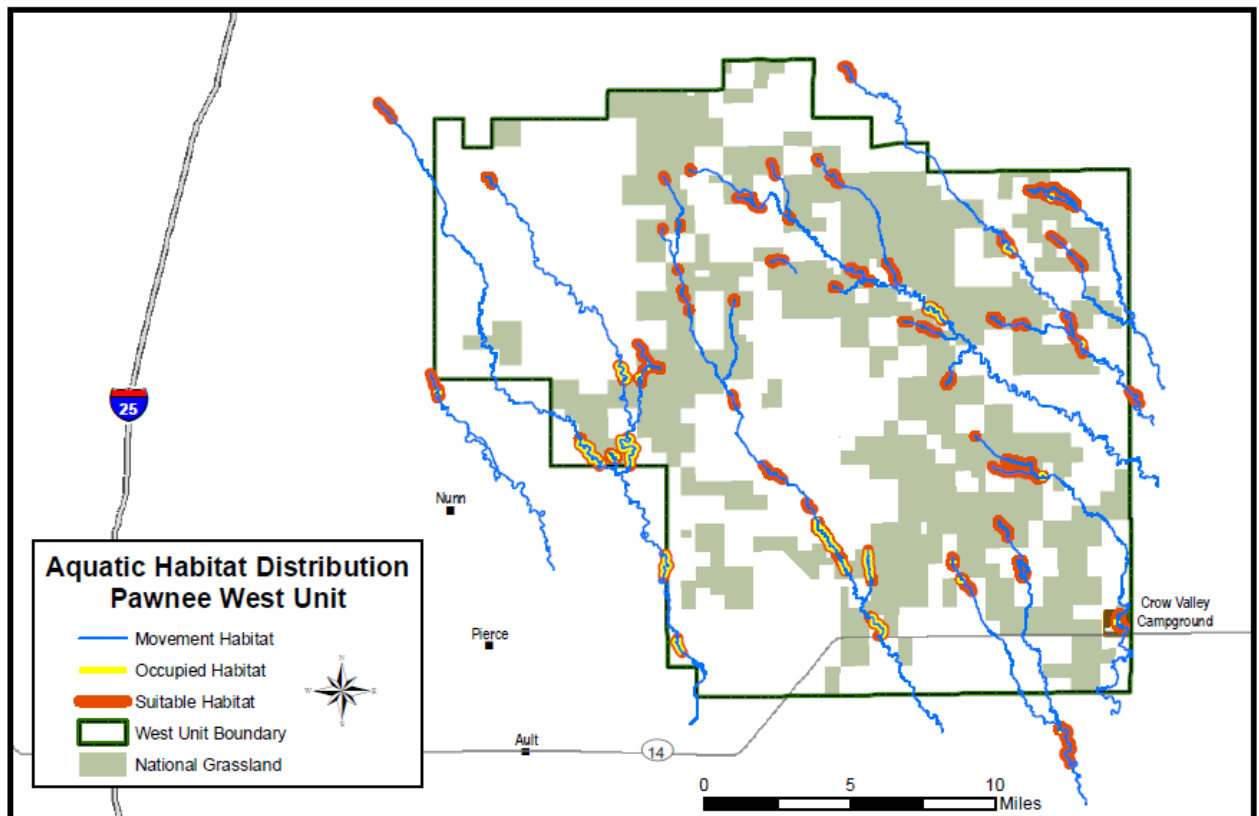
Pawnee HUC 6 Watersheds	Occupied (mi)	Suitable Habitat (mi)	Movement Habitat (mi)
Eastman Creek-Owl Creek	2.3	4.2	5.9
Headwaters Cedar Creek		0.1	0.3
Headwaters Coal Creek	1.0	1.7	12.2
Headwaters Owl Creek	0.1	0.1	1.4
Headwaters Wild Horse Creek		0.4	2.4
Howard Creek-Crow Creek	0.1	3.0	7.4
Little Owl Creek	1.8	1.9	3.5
Lower Geary Creek	0.0	1.9	5.5
Lower Little Crow Creek	0.1	3.9	5.8
Lower Willow Creek-Little Crow Creek	1.0	2.2	6.1
Middle South Pawnee Creek	2.1	3.1	3.6
Middle Spring Creek	0.7	0.7	4.5
Outlet Coal Creek			0.8
Outlet Wild Horse Creek			1.4
Sand Creek		1.5	4.1
Twomile Creek	1.0	1.3	2.1
Upper Geary Creek			0.2
Upper South Pawnee Creek	1.3	1.3	1.3
Upper Willow Creek-Little Crow Creek		4.8	16.4
Wildhorse Creek	1.2	1.4	1.6
GRAND TOTAL	12.7	33.3	86.6

For purposes of this environmental analysis, aquatic habitats were categorized into: (1) suitable habitats, defined areas of known surface water occurring along intermittent stream networks; (2) movement habitats, defined as the intermittent stream channels that during flooding events would connect patches of suitable habitat; and (3) occupied habitat, defined as habitats where native prairie fish or amphibians have been observed. To determine the amount and distribution of aquatic habitats, data were compiled from multiple sources including Kehmeier and VanBuren (1990), Nessler and others (1997), unpublished Colorado Parks and Wildlife data, and unpublished Forest Service data. The National Wetlands Inventory (USFWS 1998) and aerial photographs were used to identify additional habitats not surveyed in previous attempts or those located on private land. In addition, informal notes about sources of surface water were sought from District files.

The 1997 Forest Plan described perennial riparian sites on the Pawnee National Grassland as being limited to 30 acres; however, the actual quantity of aquatic habitat likely varies substantially based on precipitation patterns and local groundwater discharge experienced each year. Thus, in describing the quantity of suitable and occupied aquatic

habitat patches, length of habitat patch is a more suitable metric to use for fish. Through GIS analysis, approximately 86 miles of aquatic movement habitat, 33 miles of suitable habitat, and 12 miles of occupied aquatic habitat were identified through this analysis (Table 23). Aquatic habitats were more prevalent and evenly distributed on the western unit when compared to the eastern unit (Figure 14). The known perennial aquatic habitats, commonly referred to as refuge pools, experience a high degree of interannual variation in water volume and many often experience high variability in water quality parameters. In Wohl and others (2009), volume of refuge pools in some Pawnee streams changed up or down by an order of magnitude. Understandably, water quality parameters such as pH, salinity, nutrient levels, dissolved oxygen, and water clarity can change remarkably through cycles of flooding, drying, and extreme water temperature fluctuation (Entwistle and Nieves-Rivera 2014). Based on a compilation of field observations of water quality parameters, aquatic habitat sites on the Pawnee National Grassland exhibit water quality conditions that range from suitable for aquatic life to unsuitable, at least for vertebrate aquatic life (i.e., fishes and amphibians). Aquatic habitats supported by more perennial and consistent water sources exhibit more normal water quality conditions, whereas, aquatic habitats that are seasonal and entirely dependent on precipitation events exhibit the most extreme water quality conditions. Nonetheless, aquatic animals living in the aquatic habitats on the Pawnee Grassland are well adapted for surviving periods of high salinity, high water temperatures, and low dissolved oxygen levels.

Figure 28 Maps of the East and West units of the Pawnee National Grassland depicted to distribution of movement corridors, suitable aquatic habitat, and occupied aquatic habitat, Weld Cty, Colorado.



Map Date: January 14, 2014 Map Location: T:\FS\NF\5\ArapahoRoosevelt\Project\PNG\1500\NatResource\Project\1550\Project\NEPA\Minerals\Oil & Gas Leasing\GIS\MapProducts\Fish\AquaticHabitat.pdf

Current Human Disturbances and Threats to Aquatic Habitats

Most of the streams in the Great Plains have been anthropogenically altered (e.g., Fausch and Bestgen 1997, Dodds et al. 2004, Rahel and Thel 2004a, 2004b) and those alterations are believed related to current losses of endemic prairie fishes, such as the plains topminnow and other species (e.g., Fischer and Paukert 2008). Substantial modifications to prairie streams have occurred over a large portion of the species range. The conversion of grasslands from prairies to agricultural production and intense livestock grazing has degraded and simplified riparian systems, resulting in altered stream morphologies, the loss of complex stream habitats, and the loss of native fishes from prairie streams (Fausch and Bestgen 1997). Reservoirs and stream diversions constructed for irrigation and municipal uses have dramatically altered fish communities on the prairie landscape (e.g., Falke and Gido 2006), rendering vast stretches of streams uninhabitable to most native prairie stream fishes (e.g., Patton and Hubert 1993) while also permanently fragmenting prairie streams and markedly reducing the ability for prairie stream fishes to recolonize streams following droughts and floods (Fausch and Bestgen 1997, Rahel and Thel 2004a). Road infrastructure has expanded on the prairie landscape as well and has increased habitat fragmentation as more road culverts have been constructed over the Great Plains streams. Fragmentation of habitat has limited dispersal opportunities dramatically, which is fundamental to both the community dynamics and persistence of prairie fish species (Falke and Fausch 2009). Water depletions and increased rates of water depletions have reduced the amount of habitat available and the degree of isolation among population sources for prairie fishes (Dodds et al. 2004, Falke et al. 2011). Realized and potential surface water and groundwater contamination from expanded oil and gas development have degraded aquatic habitats and poses additional risk to functional habitats (e.g., Freilich 2004, Ramirez 2005, Whittemore 2007, Papoulias et al. 2013). Western mosquitofish and other non-native species, such as bullfrogs, have become more common in western Great Plains streams rendering many refuge habitats historically occupied by many native prairie fish uninhabitable (Lynch and Roh 1996, Rahel and Thel 2004a, Fischer and Paukert 2008, Pasbrig et al. 2012).

In addition, anticipated trends in climate conditions for the western Great Plains region indicate warmer temperatures will occur, which could lead to higher rates of drying for the isolated pools occupied by plains topminnow. In the streams of the south Great Plains and southwest, Matthews and Zimmerman (1990) have predicted that species occupying intermittent streams would be increasingly vulnerable to more frequent extirpations as habitats dry more frequently and for longer periods of time. While no direct link to climate change has been made for stream drying, increased consumption of groundwater and higher incidence of drought conditions have resulted in habitat losses that have completely dried many Great Plains streams (Dodds et al. 2004). Anticipated droughts and future water depletions are predicted to cause severe reductions in the amount of baseflow refugia habitats in portions of the western Great Plains (Covich et al. 1997, Falke et al. 2010).

Aquatic Communities and Aquatic Species Distributions

Great Plains fishes have evolved adaptations that allow them to survive in physiologically stressful conditions (e.g. high water temperatures, low dissolved oxygen, etc.), and compress their reproduction and growth into short periods of unpredictable high flows

(Rahel and Thel 2004a, 2004b; Wohl et al. 2009). The assemblage of species occurring in aquatic habitats on the Pawnee National Grassland varies by stream drainage, but on the whole aquatic habitats may be occupied by fathead minnows (*Pimephales promelas*), Iowa darters (*Etheostoma exile*), johnny darters (*Etheostoma nigrum*), black bullheads (*Ameiurus melas*), green sunfish (*Lepomis cyanellus*), plains topminnows (*Fundulus sciadicus*), northern plains killifish (*Fundulus kansae*), native crayfish species, northern leopard frogs (*Rana pipiens*), tiger salamanders (*Ambystoma tigrinum*), and some native mollusks (USDA Forest Service unpublished data, Colorado Parks and Wildlife unpublished data, Nessler et al. 1997). Species occur within isolated pools as assemblages of one to three species and rarely attain higher species diversity within the intermittent prairie streams on the Pawnee. Species occurring in habitats outside of the proclaimed boundary of Pawnee National Grassland, but within the same high plains watersheds include common carp (*Cyprinus carpio*) (introduced species), sand shiner (*Notropis stramineus*), white sucker (*Catostomus commersoni*), creek chub (*Semotilus atromaculatus*), brook stickleback (*Culaea inconstans*), central stoneroller (*Campostoma anomalum*), orange-spotted sunfish (*Lepomis humilis*), bigmouth shiner (*Notropis dorsalis*), red shiner (*Cyprinella lutrensis*), brassy minnow (*Hybognathus hawkinsoni*), and longnose sucker (*Catostomus catostomus*); however, collection records to date have not located these species on the Pawnee National Grassland (Nessler et al. 1997). Of these fish species, the plains topminnow and northern leopard frog are considered Region 2 Sensitive Species, both plains topminnow and northern plains killifish are Management Indicator Species (MIS) for prairie aquatic habitats on the ARP, and brassy minnow and Iowa darter have declined throughout its range and is considered a Species of Concern by all states where it occurs.

Table 28 The list of aquatic species for which environmental impacts have been examined in the Final Environmental Impact Statement. Includes special status and reason for in depth analysis. Note: Pallid sturgeon is included as federally-listed species of Platte

Common Name	Species	Status	Reason for Analysis
Plains topminnow	<i>Fundulus sciadicus</i>	Region 2 Sensitive Species MIS for prairie aquatic habitats	Species occurs in several locations across the PNG
Plains killifish	<i>Fundulus kansae</i>	MIS for prairie aquatic habitats	Species occurs in several locations across the PNG
Iowa darter	<i>Etheostoma exile</i>	Colorado Special Concern Species	Species occurs in several locations across the PNG
Pallid sturgeon	<i>Scaphirhynchus albus</i>	Endangered Species	Species adversely affected by water depletions from the Platte River Basin

The native fishes of Great Plains streams exist in a continuous state of disequilibrium between flooding and drying (Fausch and Bestgen 1997, Dodds et al. 2004., Wohl et al. 2009). Fish species assemblages on National Forest System Lands exist in isolated refuge habitats or pools of exposed alluvial groundwater. While most of these species are considered to be extremely mobile, only under certain environmental conditions (i.e., floods) does surface connectivity provide a vector for dispersal. Rapid dispersal following floods is a key strategy Great Plains fishes use to persist as refuge habitats either remain suitable or become desiccated due to local and regional weather patterns (Fausch and Bestgen 1997). The key to population persistence under this strategy is the ability of native prairie fishes to rapidly recolonize habitats, which is reliant upon stochastic precipitation events and unfragmented linear habitat networks.

Plains Topminnow

The plains topminnow occurs within the grassland portions of Nebraska, South Dakota, Wyoming, and Colorado (Rahel and Thel 2004a); however, its distribution is limited to a relatively narrow band of elevations ranging from approximately 4000 to 5600 feet above sea level (Quist et al. 2004) in association primarily with the Great Plains ecosystem (Baxter and Stone 1995). Occupied habitats occur in isolated patches and dispersal opportunities are often reliant upon the precipitation events that generate localized flooding (Rahel and Thel 2004a). Although the species occurs across a large geographic area, recent genetic work indicates that populations are genetically distinct among river drainages (Li et al. 2009), which supports the current dispersal dynamics within, but not between river basins (Falke and Fausch 2009). For the isolated habitats on the Pawnee National Grassland and likely for occupied habitat on other National Forest units, dispersal likely occurs within specific stream/drainages, but not between drainages.

Plains topminnow is overall considered “apparently secure” by Nature Serve (2012); however, a persistent downward trend in occurrence is a common theme throughout the species’ range. All states within the native range, except Oklahoma, have at one point recognized some level of conservation concern for the species. The species is presumed extirpated from Iowa, critically imperiled in Kansas and Oklahoma, vulnerable in Minnesota, Missouri, South Dakota, and Wyoming, imperiled in Nebraska, and apparently secure in Colorado (Nature Serve 2012a). The recent range-wide distributional synopsis by Pasbrig and others (2012) documented a 65% to 70% decline in observed occurrences of plains topminnow, with the greatest reductions occurring in the Platte and Republican River basins. Others (Fischer and Paukert 2008) have documented similar declines from known historic occurrences in the Platte basin of Nebraska. Even 20 years ago the species was considered historically (i.e., pre-1980) more abundant than at the time Lynch and Roh (1996) made their collections in Nebraska. In Kansas, the species has been presumed extirpated from Kansas by some (Pasbrig et al. 2012); however, the only known occurrence of plains topminnow in Kansas is from a 1963 collection in Shoal Creek and those fish were considered more of an incidental collection rather than a representation of the native fish assemblage (Haslouer et al. 2005, Haslouer 2013, personal communication). Pasbrig and others (2012) also reported significant declines (~ 90%) within the species native range of Colorado based on data supplied Colorado Parks and Wildlife; however, Colorado Parks and Wildlife (CPW) responded to the reported reduction in occurrence in a letter to the U.S Fish & Wildlife Service, noting that CPW has observed some declines in the species, but “nowhere near the losses reported by Pasbrig” (Crockett 2012). The population trend

in South Dakota is declining (Hoagstrom et al. 2006). Results from local population monitoring on the Pawnee National Grassland indicate reductions in the proportion of habitats occupied by all fish species, including plains topminnow. Willow Creek and South Pawnee Creek topminnows have remained consistently occupied by plains topminnow; however, the species has disappeared from Coal, Geary, Howard, and Wildhorse Creeks. In addition, the species has not been observed in South Pawnee Creek since 2002.

Northern Plains Killifish

The systematics of plains killifish has been contested for a long time (Rahel and Thel 2004b); however, the current scientific classification accepts two species of plains killifish occurring in North America, plains killifish (*Fundulus zebrinus*) and northern plains killifish (*Fundulus kansae*) (Kreiser 2001, Kreiser et al. 2001, and Page et al. 2013). The northern plains killifish is native to some grassland/lowland regions of Nebraska, Wyoming, Colorado and Kansas (Rahel and Thel 2004b). Most records in Colorado have referred to the native killifish as *F. zebrinus*; however, genetic phylogeographies clearly show that the plains killifish of eastern Colorado (i.e., Platte, Republican, Arkansas River Basins) is in fact the northern species, *Fundulus kansae*. The species occurs in a wide range aquatic habitats, but is most commonly associated with intermittent and perennial high plains streams and in some instances main stem and backwater areas of large rivers (Propst and Carlson 1986, Pflieger 1997). Northern plains killifish, like the plains topminnow, are tolerant of environmental extremes, such as high temperatures, low dissolved oxygen, high alkalinity, and high salinity (Woodling 1985, Rahel and Thel 2004b). Thus, the species is well-adapted for living in the intermittent pools found on the Pawnee National Grassland.

Northern plains killifish appear to have been in decline in portions of their range (Kansas, Missouri), while having remained stable in other portions of their range (Nebraska, Wyoming, Colorado) (Nature Serve 2012b). The species is has a conservation status in Kansas (Haslouer et al. 2005), yet it does not in South Dakota (Hayer et al. 2006), despite apparent restriction of native range (Hoagstrom et al. 2006). Results from local population monitoring on the Pawnee National Grassland indicate reductions in the proportion of habitats occupied by all fish species, including northern plains killifish. Owl and Little Owl Creeks remain strongholds for the species; however, the species has disappeared from Little Crow Creek and has not been observed in South Pawnee Creek since 2005.

Iowa Darter

Iowa darters range from Central Canada to New York and west to Colorado and Wyoming (Woodling 1985). In Colorado, the species occurs primarily in the lowland and grassland streams of the South Platte River (Propst and Carlson 1986). Most published synopses describe the preferred habitat for Iowa darter as cool, clear water over an organic to sandy streambed (Woodling 1985, Wyoming Game and Fish 2010). In Colorado and elsewhere in the species' western extent, they are often found in small lentic habitats such as isolated pools of intermittent streams and the backwater habitats of large rivers (Propst and Carlson 1986). Iowa darters have been documented in streams of the western unit of the Pawnee National Grassland.

Iowa darters, though widespread in extent, appear to have been in decline along the western extent of the species range as a result of habitat loss and dewatered streams (Woodling 1985, Hoagstrom et al. 2006, Wyoming Game and Fish 2010). The species is considered extirpated from Kansas (Haslouer et al. 2005), declining in South Dakota (Hoagstrom et al. 2006), needing conservation in Wyoming (Wyoming Game and Fish 2010), and vulnerable in Colorado (Colorado Parks and Wildlife 2011, Nature Serve 2011). Results from local population monitoring on the Pawnee National Grassland indicate reductions in the proportion of habitats occupied by all fish species, including Iowa darters.

Pallid Sturgeon

The pallid sturgeon is a large river fish historically occurring in most major rivers (Missouri River, Mississippi River, and the lower reaches of other large tributaries such as the Yellowstone, Platte, Kansas, Ohio, Arkansas, Red, and Sunflower; and in the first 60 miles of the Atchafalaya River) of the interior United States. Pallid sturgeon is a long-lived (>60 years) fish species and does not reach sexual maturity until 7-15 years of age. It is well-adapted for living near the bottoms of large rivers in highly turbid waters and a natural hydrograph. They prefer large riverine habitats with a diversity of depths and velocities formed by braided channels, sand bars, islands, sand flats and gravel bars, akin to an unregulated river. Due to habitat loss from flood regulation, the species range has been dramatically reduced to a few fragmented areas of the Missouri, Mississippi, Yellowstone, and Platte Rivers (U.S. Fish & Wildlife Service 1993). The species does not occur on the Pawnee National Grassland; however, water depletions from the Platte River Basin have the potential to affect this federally Endangered Species.

3.8.2 Environmental Consequences

Most environmental impacts and consequences of oil and gas development and production on aquatic ecosystems occur through indirect and cumulative effect mechanisms. Many of these impacts at the landscape scale are similar to the effects from timber extraction combined with urbanization (Smith et al. 2012). Regardless of region, these environmental impacts center on water losses reducing aquatic habitat, sediment from development reaching aquatic habitat, contaminants polluting aquatic habitat, and infrastructure (e.g., roads, pipelines) fragmenting aquatic habitat (e.g., Davis et al. 2009, Entrekin et al. 2012, Weltman-Fahs and Taylor 2013). Similarly, the anticipated development of oil and gas resources on the Pawnee National Grassland (PNG) may result in impacts to aquatic species and their habitats through the following mechanisms: (1) loss of aquatic habitat due to water depletions from regional water sources, (2) reduction in suitability of aquatic habitat where deposited sediments have reduced pool volume and altered the physical structure important to fish occurrence, (3) loss of aquatic habitat due to contaminated water sources supplying the habitat, and (4) fragmentation of aquatic habitat as a result of physical barriers created as new roads and pipelines are developed. Through either loss or reduced suitability of aquatic habitat, these mechanisms would potentially cause local population declines or extirpations of prairie fish species. The severity of these anticipated effects varies among the alternatives and is best considered along a gradient of environmental risk for habitats and the species.

Methodology

The potential effects of oil and gas related development on aquatic habitat have been examined separately by each mechanism to determine the predicted environmental consequences to prairie fish. Descriptions of each mechanism have been described and relative comparisons among alternatives in terms of direct, indirect, and cumulative effects. The effects of existing leases on the PNG have been described as a point of reference of which to base the predicted consequences of action alternatives. The analytical approach used a combination of GIS analytics, inferences drawn from published datasets on the impacts of Oil and Gas Development, and professional judgment for synthesizing analytical components together. The best available information and published datasets were sought and employed from myriad sources including USDA Forest Service, USDI Bureau of Land Management, Colorado Oil and Gas Conservation Commission, Colorado Water Quality Control Division, Colorado Parks and Wildlife, and numerous academic and research institutes. The National Forest Service Library performed literature searches for on the impacts of oil and gas development to fishes and water quality.

Incomplete and Unavailable Information

The potential impacts of unconventional oil and gas development are not fully understood. The newly available technologies being used to extract fossil fuels from deep geologic formations may pose uncertain, unquantified, and to date unrealized impacts to aquatic resources. There are uncertainties regarding the biology, dispersal, and habitat requirements for several of the prairie fish native to the Pawnee National Grassland. Water quality datasets are incomplete and efforts to collect water quality data in drilling-dense areas of the PNG do not currently occur. Our understanding of the shallow alluvial aquifer system and the connectivity of shallow groundwater to areas of suitable fish habitat is incomplete. Data regarding human-related aquatic habitat fragmentation is lacking for the PNG and surrounding areas.

Spatial and Temporal Context for Effects Analysis

The spatial context for this analysis covers the major prairie watersheds on the PNG: Kiota Creek, Owl Creek, Crow Creek, and Pawnee Creek. The time-based context of the prediction provided herein span from current day development through a 20 year period of development at the current rates of oil and gas extraction and infrastructure development as well as some anticipation of latent effects on the landscape beyond 20 years of development, including the 50-year average production life of an oil well.

Aquatic Habitats as Affected by Leasing Decision

The environmental consequences for fisheries issues have been addressed within the context of existing federal leases, federal surface ownership overlying private mineral estates, and unleased federal mineral estate. The decision space for this leasing decision is only for the unleased federal mineral estate underlying the Pawnee National Grassland. Substantial development has already occurred throughout portions of the administrative boundary. Approximately half of the suitable aquatic habitat on the PNG has unrealized risks to aquatic habitats and fish species where the Forest Service has limited control over how new infrastructure may be developed. Environmental risks for undeveloped private minerals are greater than the risks from leased, but undeveloped, federal minerals. Environmental risks to new leases would be similar leases sold under the current Forest Plan. Roughly 10 miles of suitable aquatic habitat (Coal, Geary, Little Owl, Owl, Wildhorse, and Willow Creek) on the PNG occurs over top of private mineral estates. An additional 6 miles of suitable aquatic habitat (Little Crow, South Pawnee, Wild Horse Creeks) on the PNG occurs over top of existing leases. The remaining 16 miles of suitable aquatic habitat on the PNG occur over top of unleased federal mineral estate.

Consequences of Water Depletions and Consumptive Use

Direct and Indirect Effects

Large amounts of water are used for oil and gas development and uses included dust abatement, initial drilling, pumping water and other constituents (i.e., hydro-fracturing) to stimulate oil and gas extraction at the surface, and treatment and disposal of produced water. Elsewhere in drilling-dense regions of the United States, consumptive water use and loss has shown large, sustained increases over several decades and those impacts on local water sources account for large proportions of water use (Nicot and Scanlon 2012). While the issue of water consumption anticipated under the various alternatives has been addressed elsewhere in the FEIS (Entwistle and Neives-Rivera 2014), losses of water from aquatic habitats are a major cumulative effect and not entirely discountable. Among other competing water uses on the Great Plains, water loss from aquatic habitats remains the single most critical cumulative effect causing aquatic habitat loss for prairie fish assemblages (Falke et al. 2010, 2011). Water loss from existing aquatic habitat is likely to occur as water used during oil and gas development and subsequent production is lost to the system either as a result of poor recovery during hydro-fracturing procedures or reinjecting produced water into deep geologic formations. In either case, the volume of water used during this phase is effectively removed from the hydrologic cycle (Baccante 2012). It is uncertain what sources of water would be used for future oil and gas development approved on the PNG; however, it would likely come from (1) regional groundwater sources or (2) the South Platte River. Water removed from each of these sources would result in reduced habitat availability, which would likely pose negative impacts to the native, imperiled fish species of the respective water sources. The annual sum of water used and lost from those sources based on current leases is approximately 3264 acre-feet (Entwistle and Neives-Rivera 2014). Annual water depletions with greater development and production during

the next 20 years is estimated to be 7,140 acre-feet (Entwistle and Nieves-Rivera 2014). Water depletions attributable to leases occupying the PNG vary by some alternatives; however, overall water consumption within the landscape of the PNG would likely remain the same.

Water depletions from the Colorado and South Platte Basins are anticipated to exceed minimum thresholds (U.S. Fish and Wildlife 2009, 2014) that trigger adverse impacts to listed fish species in the respective river basins, depending upon the source of water used for specific drilling permits. Additional water withdrawn from the South Platte River would cause adverse impacts to the Pallid Sturgeon (*Scaphirhynchus albus*). However, water depletions and Endangered Species Act (ESA) consultation procedures are initiated for individual projects and, in the case of oil and gas development, are proponent-based consultations. Therefore, the programmatic level analysis here only provides disclosure of the cumulative potential of water depletions under various alternatives (Table 25).

Cumulative Effects

Groundwater pumping and depletions also remove water from local aquifers under PNG lands. Pumping occurs to supply municipal and domestic water supplies. On the PNG, shallow groundwater is pumped to provide livestock watering sources. Groundwater pumping does deplete local and regional aquifers. While some of these aquifers are considered tributary and non-tributary to the South Platte Basin, we do expect aquifer depletions to grow in the future.

Table 29 Consequences of water depletions compared among alternatives.

All Alternatives	Alternative 1	Alternative 2	Alternative 3
Effects on existing leases	No Additional Leasing	No Action--leasing across PNG under current Forest Plan	Leasing under No Surface Occupancy
Approximately 43,000 acres of PNG are already leased and could have 125 wells developed on them. The estimated cumulative water depletion for existing, but undeveloped PNG leases is 6375 ac-ft	No additional effects	For 100,000 acres of available PNG mineral lease, approximately 140 wells are anticipated should leasing occur. The estimated water depletion under RFD scenario expected on unleased federal mineral estate is ~ 7140 ac-ft	Same amount of water as RFD (7140 ac-ft), but water depletions may not have connected Forest Service authorization subject to ESA Consultations

Consequences of Habitat Sedimentation

Direct and Indirect Effects

Oil and gas development includes ground-disturbing activities that increase the amount of erosion-prone area on landscapes and poses sedimentation risk to aquatic habitats. Road construction can lead to large amounts of sediment yield in prairie landscapes and sediment yield can persist for many years following initial construction. Sediment production from pipeline construction is similar to initial road construction; however, yield declines as disturbed areas revegetate. Well pads have been poorly sited in other drilling-dense regions, resulting in high runoff potential and substantial capacity for sediment transport into aquatic habitats (Drohan and Brittingham 2012, McBroom et al. 2012). In addition, sediment yields from constructed well-pad sites can be very high (e.g., >20 yds³ per acre) in dry grassland settings, similar to yields observed at large construction sites (Williams et al. 2008). These rates are much higher than the current conditions of sediment yields observed on the PNG (Entwistle and Nieves-Rivera 2014). In addition, high levels of traffic on both Weld County and Forest Service roads anticipated with more oil and gas development would increase rates of wind-born and water-born erosion processes from road-surfaces, thereby increasing the likelihood of sediment delivery to suitable aquatic habitats. These erosion processes and the vulnerabilities of soil erosion across the PNG have been addressed elsewhere in the FEIS (Entwistle and Nieves-Rivera 2014). Here, the consequences of sedimentation in aquatic habitats and biological ramifications will be addressed.

The ultimate fate and consequences of sediment deposition into the small aquatic habitats could reduce the habitat suitability for the native prairie fish community by reducing aquatic habitat volume, reducing pool depths, and facilitating the conversion of suitable fish habitat to shallow wetland habitat incapable of supporting the prairie fish community. It is well-known that sediment deposited into stream habitats can alter and, in some cases, eliminate fish assemblages (Waters 1997). These shifts are caused by sediment covering structurally-diverse streambed habitat and reducing pool quantity and quality (Waters 1997). In Missouri, fish with feeding ecologies and spawning habitat requirements similar to plains topminnows, northern plains killifish, and Iowa darters were markedly reduced by stream sedimentation (Berkman and Rabeni 1987, Rabeni and Smale 1995). In addition, the effective life-span and habitat suitability of other aquatic habitats has been dramatically reduced by interception of deposited sediments elsewhere in the Great Plains (Gleason and Euliss 1998). Sediments deposited into suitable habitats on the PNG are likely to persist for a long-time (~10 years) given the low likelihood of large precipitation events capable of scouring out depositional sediment. Thus, deposition of sediment into suitable habitats would likely result in the conversion of fish habitat to shallow wetlands with little surface water. In sum, although the specific mechanisms for potential sedimentation effects to PNG fishes vary by species, all three species would suffer negative impacts as a result of reduced pool habitat, alteration in food availability, and degraded spawning habitat.

Entwistle and Nieves-Rivera (2014) identified areas with the greatest potential to deliver sediment into aquatic habitats for the PNG. Some areas of existing leases fall into the identified susceptibility areas that lie in close proximity to suitable habitats. These habitats (e.g., Coal Creek, Little Crow Creek, Owl Creek, South Pawnee Creek) are at greatest risk of sedimentation impacts. Sedimentation risks can be managed to acceptable levels by separating the aquatic habitat from the sediment source. The key to this approach is to ensure that not only is there sufficient buffering distance, but also that landforms and vegetation exist to adequately filter anticipated volumes of sediment (Waters 1997). The application of aquatic habitat buffers in small plains streams has been demonstrated to improve habitats degraded by sedimentation (e.g., Shields et al. 1995, Rabeni and Smale 1995).

Sedimentation Risks to PNG Fishes by Alternative

Direct and indirect effects of sedimentation causing loss or degradation of aquatic habitat will vary depending on how much new oil and gas development occurs and the proximity of new oil and gas development to suitable aquatic habitats. The effects described above should be seen as risks that are common to all alternatives with the probability of resource risk changing with increasing displacement of the risk from the aquatic habitat. The impacts of sedimentation to aquatic habitat resulting from oil and gas development under various leasing decisions can be estimated based on proximity analysis of how close or far erosion risks are separated from aquatic habitats. Existing oil and gas infrastructure on the PNG has been developed within 100 feet of adjacent aquatic habitat (e.g., API # 05-123-13427; API # 05-123-13275; API # 05-123-21580), so it is reasonable to assume that continued development under the Forest Plan could result in new infrastructure (i.e., wells, roads, pipelines) being developed within close proximity (< 650 feet or 200m) to suitable aquatic habitats. Development within close proximity to aquatic habitat would pose sedimentation risks to valuable aquatic habitat, resulting in impacts to fish.

The relative risks of sedimentation impacts to PNG fish vary by alternative and are based on the proximity of susceptible erosion areas to suitable habitat patches. A GIS proximity analysis was used to determine miles of suitable habitat that would potentially be degraded by sedimentation. Based on highly erosive soils identified within 650 feet of suitable habitat patches, habitats were classified as either susceptible to sedimentation or not as a result of well pad, road, or other infrastructure development. Comparisons were made within the context of the type of mineral estate (i.e., federal-leased, private estate, or federal-available) to attribute risks to suitable aquatic habitats under each alternative (Table 26). Sedimentation risks are highest on private mineral estate due to the limited ability of surface ownership to stipulate environmental protections. Sedimentation risks are second highest on currently leased federal minerals due to insufficient protections provided by the Forest Plan (e.g., wells have been and may continue to be located within 200m of suitable habitat; in some areas erosion beyond 200m may still cause sedimentation of suitable aquatic habitats). Sedimentation risks are lowest on unleased federal minerals; however, sedimentation risks to remaining suitable aquatic habitats may be higher under certain leasing alternatives (i.e., Forest Plan). Within the context of existing leases, private mineral estate under PNG, and federal mineral estate under PNG, conclusions can be drawn about to a degree to which suitable habitats are at risk to sedimentation. Under Alternatives 1 and 3, additional sedimentation risks associated with Oil and Gas development would be limited. Permits for access roads and pipeline infrastructure are expected to occur, which may cause minor sedimentation of habitats. Under Alternative 2, additional sedimentation risks associated with Oil and Gas development would rise for most of the suitable aquatic habitat. Well pad development, new roads, and new pipelines would increase sedimentation risks, which may significantly reduce the quantity and quality of suitable aquatic habitat on the PNG. Approximately 15.1 miles of suitable aquatic habitat would be highly susceptible to sedimentation should any development occur within 200m (650 ft). Approximately 5.9 miles of suitable aquatic habitat would be susceptible to sedimentation even if development were to occur beyond 200m. Suitable aquatic habitat occurring within the Little Owl Research Natural Area would be largely protected from sedimentation effects even under Alternative 2.

Cumulative Effects

Other activities on the PNG also contribute to sedimentation in aquatic habitats, including, season long grazing and modest levels of road maintenance. Grazing on the PNG is expected to remain near current rates in the future. Road maintenance on the PNG is expected to continue at current rates, but may also increase as new roads are constructed. While both of these activities

are known to cause sedimentation to aquatic habitats, current amounts of sedimentation to aquatic habitats has not been quantified for aquatic habitats across the PNG. It is reasonable to conclude that sedimentation from these cumulative actions will continue to occur at current rates and it is uncertain if current sedimentation rates are diminishing suitable habitat.

Table 30 Consequences of habitat sedimentation to 33 miles of suitable aquatic habitats on the Pawnee National Grassland compared among alternatives.

All Alternatives	Alternative 1	Alternative 2	Alternative 3
Effects on existing leases plus effect of private mineral estate under PNG.	No Additional Leasing	No Action--leasing across PNG under current Forest Plan	Leasing under No Surface Occupancy
<p>Over 16 miles of suitable aquatic habitat is at a moderate to very high risk of sedimentation reducing the capacity of the habitat to support prairie fish due to existing leases and private mineral estates.</p> <p>2.5 miles of suitable habitat are at high risk of sedimentation on existing leases.</p> <p>5.7 miles of suitable habitat are at very high risk of sedimentation on private mineral estate.</p>	<p>FS authorized activities would contribute minimal additional risks of sedimentation to 16 miles of suitable aquatic habitat on unleased federal mineral estate. Sedimentation risks may be displaced from NFSL to adjacent private lands, which may result in habitat loss on adjacent lands or as result of downstream sediment transport.</p>	<p>Sedimentation risks will rise for 32 miles of suitable aquatic habitats.</p> <p>Development within 200m = 15.1 miles of suitable habitat is at high risk to sedimentation.</p> <p>Development beyond 200m = 5.9 miles of suitable habitat is at moderate risk to sedimentation.</p> <p>Risks from FS authorized actions will remain low on Little Owl Creek (1 mile) within the Research Natural Area.</p>	<p>FS authorized activities would contribute minimal additional risks of sedimentation to 16 miles of suitable aquatic habitat on unleased federal mineral estate. Sedimentation risks may be displaced from NFSL to adjacent private lands, which may result in habitat loss on adjacent lands or as result of downstream sediment transport.</p>

Consequences of Environmental Contaminants to Aquatic Habitat

Direct and Indirect Effects

Oil and gas development and production poses risk of environmental contaminants reaching aquatic habitats. Risks of leaks, spills, and other losses of containment exist during much of the development and production phases; however, the greatest risks are associated with the

collection of hydrocarbons at the surface, transport and storage of hydrocarbons, down-hole pumping of water, sand, and chemicals, and collection, containment, and disposal of flow-back and produced water. Among these risks, flow-back and produced water (collectively referred to as produced water, henceforth) poses the most significant risk to aquatic habitats due to the sheer volume of produced water managed by the industry (Ahmadun et al. 2009). The proximity of these risks to important aquatic habitat areas controls the fate and ultimate consequence of environmental contaminants reaching aquatic habitats (Entrekin et al. 2013). Water resource features vulnerable to contamination have been identified as either surface waters or groundwater influence zones (Entwistle and Nieves-Rivera 2014). Here, a brief review covers potential contaminants used for oil and gas development, contaminant fate and persistence in surface and groundwater, and the environmental consequences of contaminants to fish.

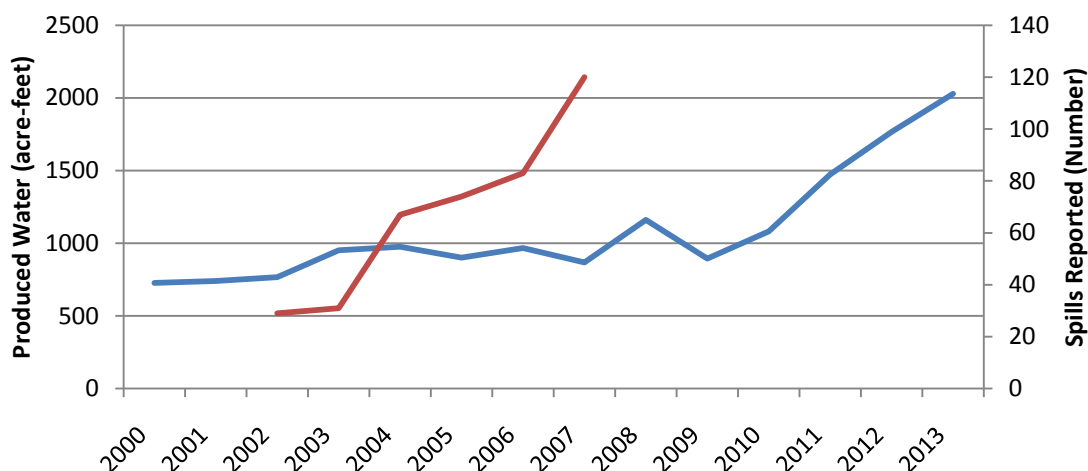
For unconventional oil and gas development, contaminant transport pathways and risks have not been well-studied as much of the “unconventional” technology has been developed within the past 10 years (Jackson et al. 2013). Areas of dense development (e.g., Pennsylvania, Wyoming, Colorado) pose the largest risks as the hydro-fracturing processes and well-cementing issues around “active” and “closed” wells may create vectors for contaminants and expedite contaminant transport to ground and surface water resources (e.g., Myers 2012, Jackson et al. 2013). Aquitards (i.e., zones of relatively impermeable sediment) can trap and prevent the flow of contaminants released at the surface from moving into deep aquifers (Cherry et al. 2004); however, the shallow clay-based aquitards on the Pawnee National Grassland also funnel ground water in the unconfined alluvial aquifer into suitable fish habitats. Thus, while aquitards protect deep aquifers (e.g., Ogallala, Brule), they may concentrate and deliver contaminants released at the surface to suitable habitats.

The process of pumping water and fracturing fluids into drilled wells to create high pressure underground is referred to as hydro-fracturing. This process causes fractures in the dense geologic formations such as shale, which releases oil and gas resources, and also results in the production of large volumes of water mixed with oil, gas, and other substances at the surface. Both hydro-fracturing fluids and produced water contain potential environmental contaminants and can be viewed as risks to groundwater and surface water quality (Gordalla et al. 2013). While water and sand are the chief constituents used in hydro-fracturing fluids, several known toxic substances are often used in hydro-fracturing fluids (Vidic et al. 2013, Kassotis et al. 2013). Conversely, as hydro-fracturing fluid is pumped into the well, hydrostatic pressure causes substances trapped in deep geologic formations to dissolve in the water. This aqueous solution becomes a mixture of oils, gases, and water with constituents from fracturing fluids as well as dissolved constituents from geologic formations that eventually return to the surface at the well head. From there, the gases and oils are separated from the produced water and produced water is typically handled as wastewater.

Produced water is the single largest waste stream from the oil and gas industry and with the volume of material to manage (Ahmadun et al. 2009), accidental spills and releases of produced water into the environment is inevitable. Approximately 50,000 acre-feet of produced water are generated in Colorado annually and while the majority is evaporated or reinjected (Clark and Veil 2009, COGCC 2014), produced water can be permitted for discharge into streams, percolation into the ground, or put to beneficial use (e.g., irrigation). In Weld County, produced water is disposed by reinjection of the water along with constituents underground or through evaporation and percolation of water in pits (COGCC 2014). Although oil and gas operators in Weld County reportedly generated 12,000 acre-feet of produced water in a 10 year period, the

rate of water produced at well heads has been steadily increasing since 2007 (Figure 15). In addition, rates of produced water increase as wells age (Veil et al. 2004). The rate of produced

Figure 29 Quantity of produced water (blue line) and number of spills (red line) reported to Colorado Oil and Gas Conservation Commission for Weld County Colorado from 2004 to 2013. Source: Colorado Oil and Gas Conservation Commission Online Database.



water generated is expected to increase over the next 20 years, so annual rates of produced waters could easily double or triple the annual rate of 2,000 acre-feet of water. The importance of this quantity of produced water and constituent substances is how it is handled, treated, and disposed as wastewater. In addition, disposal via percolation into the ground from unlined evaporation pits represents a large potential risk to neighboring groundwater influence zones that supply water to suitable habitats.

Similarly, rates of spills and releases have also been on the rise in recent years (Earthworks 2008, Figure 15). Statewide from 2003 to 2008, roughly 20% of spills have affected surface or ground water resources; however, 47% of spills in Weld County affect water resources. In addition, the rate of spills/releases to the environment in Weld County has been increasing approximately 80% per year (Earthworks 2008). Spills and chemical releases often receive media attention (Banerjee 2013, Finley 2011); however, water quality testing is not routinely performed and formal pre-drilling to post-drilling water quality monitoring program does not occur in Weld County, Colorado. Thus, there is little information available regarding what substances are released into the environment when spills occur.

The constituency of produced water has received some study and varies in composition based on the type of oil or gas being produced (Veil et al. 2004). For gas production, produced waters contain inorganics (e.g., chloride and bromine salts, metals), organics (e.g., phenols, alkanes, aromatic hydrocarbons), and radio-active materials in concentrations in excess of toxicity standards for aquatic life (Alley et al. 2011). Produced water from gas production contains high levels of chloride salts or other brines (Alley et al. 2011, Farag et al. 2012). Concentrations of salts and constituent substances increases with time as the wells age (Veil et al. 2004). These substances reduce immune function (e.g., Reynaud and Deschaux 2006), disrupt reproductive function (e.g., Sumpter and Jobling 1995, Nicolas 1999, Kidd et al. 2007), delay or halt embryonic development (e.g., Carls et al. 2008, Farag et al. 2012), lead to mortality (e.g., Cairns and Nebecker 1982, Woltering 1984, Vittozi and De Angelis 1991, Farag et al. 2012), and reduce

both quantity and diversity (e.g., Albers et al. 1985, Thienpoint et al. 2013) in fish and other aquatic animals. Several of these impacts have been documented in fathead minnows, both a common laboratory animal and inhabitant of aquatic habitats on the PNG.

Table 31 Concentration of oil & gas related constituents (mg/L) in surface water, ground water, and produced water within 0.25 mile of PNG lands, Weld Co.

An asterisk (*) indicates values exceeds known toxicity level for fish or water quality standard. N-Hexane, naphthalene, methane, magnesium, iron, oil & grease, fluoride, ethylbenzene, bicarbonate, calcium, chromium, barium, arsenic, strontium, sulfate, diesel organics, gasoline organics, thorium, and xylenes were detected but below known toxicity values for fish. (1) Value is just under known toxicity level, but reproductive physiology is likely affected at this level.

Constituent	Surface Water	Ground-water	Produced Water
Benzene (mg/L)	0.0005	0.0005	5.2*
Bicarbonate (mg/L)	406*	238	152
Cadmium (mg/L)	0.001*	0.001*	0.001*
Chloride (mg/L)	131	25.8	5799
Lead (mg/L)	0.005	0.0139	0.005
Potassium (mg/L)	38.8	9.53	11.7
Sodium (mg/L)	411	145	3999
Toluene (mg/L)	0.0005	0.0005	6.14 ¹
Cesium 137 (pCi/L)	12.0	0.0	9.0
Radium 226 (pCi/L)	0.0	0.0	19.0
Radium 228 (pCi/L)	50.0*	0.0	30.0*
Xylene (mg/L)	0.0005	0.0005	2.71*
Uranium (µg/L)	66.7	0.001	8.9

Existing Water Quality

To discern evidence of risk to ground and surface waters from oil and gas activities on the PNG, water quality data were queried from COGCC and the Colorado Water Quality Control Division on February 19, 2014. Seven water quality collection sites were located within a quarter-mile of PNG lands with the majority of sample sites located near municipalities (e.g., Nunn, Briggsdale, Raymer). Contaminants tested were compiled and those exceeding safe levels (Woltering 1984, Vitozzi and DeAngelis 1991, Alley et al. 2011, and EPA 2014) were used to determine existing risk; however, this should not be considered exhaustive and accuracy of contaminant measurements is unclear as data were collected by different entities and processed by different laboratories. Several BTEX, PAH, and other hydrocarbon substances along with salts, metals, and radioactive elements were detected in produced water near the PNG (Table 27). In some cases, surface water and ground water were contaminated by some of those substances. It should be noted that while these observations represent some conditions found near the PNG, they are not comprehensive because mandatory ground and surface water quality testing is not required at this time in Colorado.

Water quality standards for surface waters on the PNG are currently set for protections to agricultural systems and not aquatic life because the beneficial uses in suitable aquatic habitats on the PNG are classified as agricultural only (Colorado Water Quality Control Division, 2014 pers. comm.). Standards for agricultural beneficial uses are lower than standards for aquatic life

beneficial uses. This means that contaminants exceeding standards for aquatic life in suitable aquatic habitats on the PNG likely would not trigger a State regulatory response even if samples with exceedances were detected.

Contaminant Fate

It is uncertain how long contaminants will persist in surface and groundwater sources and thus how long they may disrupt biological mechanisms. Contaminant degradation rates span 1.5 to 5 years for BTEX contaminants (Cozarelli et al. 2010); however, degradation of all oil and gas contaminants varies from short term (i.e., months) to long-term persistence (i.e., > 10 years) depending on soil media type and hydrogeological factors (Farhadian et al. 2008, Baedecker et al. 2011). In addition, toxicity of contaminants released into the environment can be amplified by exposure to sunlight (Oris and Giesy 1987 [PAH]), while PAH, some BTEX, other contaminants bioaccumulate through aquatic food webs resulting in cascading impacts to aquatic ecosystems (Neff 2002).

Contaminant Risks to PNG Fishes by Alternative

Based on known fish responses to contaminants and the persistence of contaminants in the environment, potential contamination to surface or ground water resources could easily cause them to become degraded to the point where suitable aquatic habitats are no longer capable of supporting the native prairie fish. In addition, the current rates of spills and environmental releases to surface water and groundwater are expected to increase with time. Over a 20 to 50 year period the likelihood of fish being adversely affected by contaminants is high. This degradation of water quality in suitable habitats would be an indirect effect of permitted oil and gas development activity on the PNG. The risks of contamination and consequence to PNG fishes was compared among alternatives by performing proximity analysis similar to the approach used to determine potential impacts of increased sedimentation. In summary, the long-term or short-term loss of suitable habitat is likely given the increased risk of water pollution due to accidental releases of hydrocarbons and other industrial chemicals, such as hydro-geologic fracturing fluids and produced water and these risks vary among alternatives. Under the No Action alternative, risks of environmental contaminants in aquatic habitats would increase from 16 miles of suitable aquatic habitat at very high to high risk to 33 miles (100% of PNG) of suitable aquatic habitat at high risk (Table 28). Under the No Leasing and No Surface Occupancy alternatives, risks of environmental contaminants in aquatic habitats would not increase for aquatic habitats on the PNG.

Cumulative Effects

Grazing and Oil and Gas Development have been and continue to be the primary land uses for the Pawnee National Grassland. These land uses have resulted in contamination of aquatic habitats through either nutrient enrichment or the release of toxic chemicals into the environment. These impacts are expected to continue in the future. Oil and Gas development under some alternatives is expected to increase in the future and would likely contribute to additional toxic chemical releases to the environment. In addition, recreational shooting occurs in some locations and contributes to increased levels of heavy metals (i.e., lead), which can cause adversely affect water quality and fish. This use is expected to continue and perhaps expand in the future. Additions of leads and other heavy metals would add to the environmental risks of contaminants in aquatic habitats.

Comparison of Effects among Alternatives

Table 32 Consequences of habitat contamination compared among alternatives.

All Alternatives	Alternative 1	Alternative 2	Alternative 4
Effects of Existing Leases	No Additional Leasing	No Action—leasing across PNG under current Forest Plan	Leasing under No Surface Occupancy
<p>Over 16 miles of suitable aquatic habitat is at a moderate to very high risk of contamination adversely affecting fish & ability of habitat to support fish due to existing leases and private mineral estates.</p> <p>10+ miles of Coal, Owl, Wildhorse, and portions of Willow Creek habitats are at very high risk of contamination due to private minerals.</p> <p>6+ miles of Little Crow & S. Pawnee Creek habitats are at high risk of contamination due to existing leases.</p>	<p>Increased risk from contaminated surface or ground water will be confined to private lands.</p> <p>FS authorized activities would contribute minimal additional risks of contamination to 16 miles of suitable aquatic habitat on unleased federal mineral estate. Contamination risks may be displaced from NFSL to adjacent private lands.</p>	<p>Contamination risks will rise for 31 miles of suitable aquatic habitats. No suitable habitat areas would be protected from contaminant risks</p> <p>Risks from FS authorized actions will remain low on Little Owl Creek within the Research Natural Area.</p>	<p>Increased risk from contaminated surface or ground water will be confined to private lands.</p> <p>FS authorized activities would contribute minimal additional risks of contamination to 16 miles of suitable aquatic habitat on unleased federal mineral estate. Contamination risks may be displaced from NFSL to adjacent private lands.</p>

Consequences of Habitat Fragmentation

Direct and Indirect Effects

Existing infrastructure on the Pawnee National Grassland fragments both suitable habitat and movement corridors; however, we do not currently have a field-based assessment of barriers to fish movement. Reservoirs and stream diversions constructed for agricultural and residential uses occur on most of the major stream drainages. Some of these structures still exist on federal lands; however, most occur on private lands. Some reservoir and diversion dams have been abandoned over the years and many of these have been breached by flooding and were never rebuilt. These water development sites can render vast stretches of streams uninhabitable to most native prairie stream fishes (e.g., Patton and Hubert 1993) and thus, permanently fragmenting prairie streams. In addition, road infrastructure on the Pawnee National Grassland varies from primitive two-track roads to major county roads and state highways. As these roads cross the landscape, they also cross streams and the majority of stream crossings serve as barriers to fish movement due to under-sized culverts that convey water too swiftly and pose jumping heights that exceed the physical abilities of the native prairie fishes. Crossing structures along this

gradient of primitive to well-developed roads vary in the degree to which they may fragment habitat. For example, some lightly-used administrative roads cross streams with open-water fords and do not usually fragment habitat; whereas, major county roads are full-prism roads and cross stream areas with large fills and small culverts that do fragment habitat. While diversion structures are not expected to increase as a result of expanded oil and gas infrastructure development and use, the impact on habitat fragmentation remains. Road construction, on the other hand, is expected to increase as a result of new road and pipeline infrastructure. New infrastructure will likely pose additional fragmentation risk to suitable habitat and movement corridors as new crossings traverse over or under stream networks. Approximate locations of new roads and pipelines are indeterminate at this time. Thus, how the new linear infrastructure features interact with linear stream habitat features is unknown. However, relative comparisons of the degree to which infrastructure crosses and potentially poses risk of habitat fragmentation can be described and compared among alternatives.

Table 33 Distribution of potential fragmentation sites along streams on the Pawnee National Grassland, Weld Co., Colorado.

GIS generated results from Colorado Division of Water Resources and USDA Forest Service.

Stream Name	Crossings	Diversions
Unnamed Creeks	57	99
Cedar Creek	5	0
Coal Creek	27	42
Crow Creek	3	12
Eastman Creek	3	4
Geary Creek	13	10
Howard Creek	10	11
Little Crow Creek	3	2
Little Owl Creek	14	32
Little Sand Creek	5	4
Lone Tree Creek	10	11
Owl Creek	12	17
Pawnee Creek	4	0
Robinson Creek	2	0
Sand Creek	9	8
South Pawnee Creek	12	275
Spring Creek	6	40
Twomile Creek	4	0
West Fork Willow Creek	4	22
Wild Horse Creek	11	55
Wildhorse Creek	2	2
Willow Creek	11	112
Grand Total	227	758

In order to determine areas of greatest fragmentation risk, a GIS analysis was performed to capture the existing amount of potential fragmentation as a result of diversions/reservoirs (Colorado Division of Water Resources 2013) and road/stream intersections (USDA Forest Service, unpublished data). Based on this query of available data, over 200 road crossings and over 700 past water diversion sites occur on PNG streams. Although not all of these sites occur on federal lands, these features still disrupt movement into suitable habitats from refuge areas. Some streams have few fragmentation sites given their length (e.g., Crow Creek, Robinson Creek); whereas, other streams have a high number of potential fragmentation sites (e.g., Coal Creek, Little Owl Creek, South Pawnee Creek).

There are roughly 30 miles of additional road construction anticipated with new leases and associated oil and gas infrastructure development. This anticipated habitat fragmentation will markedly reduce the ability for prairie stream fishes to recolonize streams following droughts and floods (Fausch and Bestgen 1997, Rahel and Thel 2004a). Fragmentation of habitat has limited dispersal opportunities dramatically, which is fundamental to both the community dynamics and persistence of prairie fish species (Falke and Faush 2009). Because determining the impacts of habitat fragmentation from additional oil and gas development requires site-specific proposals, at the programmatic level we merely describe what fish habitat resources are at greatest risk. Based on the distribution of suitable habitats and existing fragmentation across the PNG, additional fragmentation of all streams and suitable habitat would be detrimental to persistence of the native prairie fishes. Key streams with suitable and occupied habitat most susceptible to additional fragmentation are Owl Creek, Little Owl Creek, Coal Creek, and South Pawnee Creek. Any additional road or pipeline development crossing suitable habitat or movement corridors should be provided for upstream-downstream passage of the full suite of prairie fishes occurring on the PNG. In addition, where permits for road use of existing Forest Service Roads are authorized, existing fish barriers should be replaced during the process of bringing the roads up to Forest Plan and Forest Service Transportation standards.

Under the No Action Alternative, additional habitat fragmentation is possible and likely to occur. The degree and extent to which habitat will be fragmented cannot be determined without site-specific proposals. Under the No Leasing and No Surface Occupancy alternatives, there is limited potential for additional fragmentation as a result of activities on PNG. Incidence of road permits may increase and the FS may have opportunities to reduce additional habitat fragmentation.

Cumulative Effects

Grazing and Oil and Gas Development have been and continue to be the primary land uses for the Pawnee National Grassland. Minor amounts of recreation also occur on PNG lands. Grazing and recreation management is unlikely to cause the construction of additional fish passage barriers. Water storage or diversion projects are unlikely to be proposed for PNG lands as there is little water to make such proposals viable. Depending on the type of lease, fish passable structures may be constructed. Additional stream crossing infrastructure may be constructed for existing Oil and Gas leases or private mineral access. However, the Forest Service may either choose not to or may not be able to require fish passable structures on PNG lands. The PNG lands comprise a scattered ownership. The interspersed private lands likely pose higher risks overall for additional road or pipeline construction for both Oil and Gas and other types of development.

Comparison of Effects Among Alternatives

Table 34 Consequences of habitat fragmentation compared among alternatives.

All Alternatives	Alternative 1	Alternative 2	Alternative 4
Effects on existing leases	No Additional Leasing	No Action—leasing across PNG under current Forest Plan	Leasing under No Surface Occupancy
Baseline conditions present plus potential fragmentation of any aquatic habitat on Little Crow Creek, upper portion of Owl Creek, portions of Howard Creek, large extents of Wildhorse Creek (east side), large extents of South Pawnee Creek, nearly all of Kibben Creek	Limited additional fragmentation as a result of activities on PNG. Incidence of road permits may increase and the FS may have opportunity reduce additional habitat fragmentation.	Risk of additional aquatic habitat fragmentation is likely on any aquatic habitat, especially within highest potential development areas. Risks from FS authorized actions will remain low on Little Owl Creek within the Research Natural Area.	Limited additional fragmentation as a result of activities on PNG. Incidence of road permits may increase and the FS may have opportunity reduce additional habitat fragmentation.

Determination of Effects to Species and Rationale

The purpose of this section is to provide an analysis of the anticipated consequences to federally-listed, regionally-sensitive, and management indicator species as a result of the various alternatives. This section summarizes the overall effects of oil and gas leasing decisions to fish species.

Threatened and Endangered Species (ESA)

Pallid sturgeon is a federally-listed species occurring downstream in the Platte River, Nebraska. Under ESA and the Platte River Recovery Program, water depletions from the Platte Basin have been determined to cause a detrimental loss of habitat available to the species downstream in Nebraska. Within the programmatic oil and gas leasing decision, this species would only be affected by downstream water depletions in the South Platte Basin. The leasing decision alone will not cause additional water depletions. Rather, water depletions would occur at the site-specific scale (i.e., APD), when wells would be authorized to be developed. In context of the programmatic leasing decision, water depletions have been cumulatively summed based on the RFD (Reasonable Foreseeable Development) scenario and the forecasted effects determination has been provided for the leasing alternatives. Existing leases are anticipated to cause a 6,375 ac-ft of water depletions from the South Platte River. Under the No Leasing alternative, it is likely that there would be collectively fewer wells and thus less water needed for the development of oil and gas resources; however, most water used for well-drilling, development

and production would occur on adjacent private lands. It is not determinable how much water would be used to develop infrastructure on adjacent lands, but it is reasonable to assume that less water would be depleted from the South Platte Basin under the No Leasing alternative compared to others. Additional leases under the No Action alternative would result in additional water depletions subject to Section 7 ESA consultation. Based on the RFD and assumptions of development, the forecasted amount of additional water depletions to the South Platte River would be approximately 7,140 ac-ft to be consulted upon during the site-specific analysis. Under the No Surface Occupancy alternative, additional well pad development, well drilling, and most of the other activities associated with water depletions would not occur on lands administered by the Pawnee National Grassland. Oil and gas infrastructure that would have been developed on PNG would be displaced to adjacent lands and thus, the forecasted water depletion for the South Platte assumed for the No Action alternative, 7,140 ac-ft, would also occur, albeit on surface ownerships that may or may not be subject to Section 7 ESA consultation for downstream water depletions.

Under those forecasted water depletions, both the No Action Alternative (No. 2) and No Surface Occupancy Alternative (No. 3) would eventually lead to similar amounts of water depleted from the South Platte Basin. These alternative leasing decisions are expected to lead toward 7,140 ac-ft of new water depletions largely from sources in the South Platte Basin. Most of these water depletions would have a federal nexus for project proponents, exceeding the *de minimus* that the U.S. Fish & Wildlife Service established in 2006 (U.S. Fish & Wildlife Service Biological Opinion 2006). The No Leasing Alternative (No. 1) is not expected to lead toward an increase in the amount of water depleted from the South Platte Basin because there would not be a large demand for water and thus no additional water depletions as related to this leasing decision. Actual effects determinations to pallid sturgeon have not been made for this leasing decision because water depletions are managed site-specifically during the “APD” stage and the responsibility of project proponents.

Forest Service Sensitive Species

The plains topminnow is a fish species on the Regional Forester’s Sensitive Species List for the Rocky Mountain Region. This species occurs in roughly 4.5 miles of the occupied aquatic habitat across the grassland. The most robust population occurs in West Willow Creek, while smaller and more diffuse populations occur in South Pawnee Creek and its tributary Kibben Creek. The species has disappeared from all other known habitats on the PNG. The species’ stronghold in Willow Creek occurs in an area identified by the BLM as having “moderately high development potential” (i.e., 10-20 wells per Township) and occurs on top of a private mineral estate (i.e., O&G development could occur in close proximity to sensitive habitats without controls/stipulations by the surface owner). Thus, this particular plains topminnow habitat is already at high risk from reduced habitat suitability as related to sedimentation, contamination, and fragmentation. Some habitat in South Pawnee Creek is already at a moderate risk due to existing leases and infrastructure in close proximity to occupied habitat. Only 38% of habitat currently occupied by plains topminnow in South Pawnee Creek is relatively protected from the potential impacts of Oil and Gas Development. The following determinations have been made in accordance with FS Biological Evaluation Standards (FSM 2672.42).

Table 35 Summary of the distribution, extent, and current status of fish occurrence in occupied aquatic habitats on the PNG, Weld Co, Colorado.

The proportion of habitat at high, moderate, and low risk are indicated for each drainage. Superscripts indicated streams historically occupied by plain topminnow (1) and northern plains killifish (2).

Stream	Miles	Last Year Occupied	Current Species Present	Private Mineral Estate (High Risk)	Leased Federal Minerals (Moderate Risk)	Available Minerals (Low Risk)
Coal Creek¹	1.01	2002	NONE	100%		
Geary Creek¹	0.04	2001	NONE	100%		
Howard Creek¹	0.09	2006	NONE			100%
Little Crow Creek²	0.13	2013	Iowa darter, fathead minnow		100%	
Little Owl Creek²	1.82	2013	fathead minnow, Iowa darter, black bullhead, plains killifish	17%		83%
South Pawnee Creek¹	3.38	2014	fathead minnow, green sunfish, plains topminnow		62%	38%
Spring Creek	0.68	1999	green sunfish			100%
Twomile Creek	0.99	2002	green sunfish			100%
Wildhorse Creek¹	1.24	2012	NONE	100%		
Willow Creek¹	1.03	2014	fathead minnow, green sunfish, plains topminnow, black bullhead, Iowa darter	92%		8%

-
- Alternative 1 – No Additional Leasing of Federal Minerals. This alternative would have few additional impacts to the either 3.5 miles of occupied or 16.1 miles (~50%) of suitable aquatic habitat for the plains topminnow. Occupied aquatic habitat in South Pawnee Creek would remain protected from the anticipated impacts associated with Oil and Gas Development. Most occupied aquatic habitat in “Kibben Creek” (i.e., tributary to South Pawnee) and in West Willow Creek may remain at a high risk of degradation. Populations in these habitats are already at high risk of extirpation based on proximity of existing risks and minimal control over development on National Forest System Lands. The 3 miles of occupied aquatic habitat in South Pawnee Creek and 13.1 miles of additional suitable aquatic habitat may be subjected to some additional fragmentation related to Forest Service permits for road access and pipelines; however, the agency will have more control over these permitted actions than well-drilling. Current populations and the capacity of suitable aquatic habitats to support plains topminnow would not be adversely affected. The likelihood that plains topminnow will remain a viable species on the PNG is moderate under this alternative. Therefore, Alternative 1: **“May adversely impact individuals, but not likely to result in a loss of viability in the Planning Area, nor cause a trend toward federal listing”** on the plains topminnow on the PNG. Cumulative effects of Oil and Gas development on adjacent lands may result in degradation of suitable aquatic habitats and possibly extirpations from locally occupied habitats; however the full extent of those impacts are indeterminable.
 - Alternative 2 – No Action, Development Under Forest Plan. This alternative is expected to result in additional long-term losses or reductions to 31 miles (95%) of both suitable and 12 miles of occupied aquatic habitat for plains topminnow. In addition to the “at risk” occupied aquatic habitats in Willow and Kibben Creeks, habitats in South Pawnee Creek and the 15 miles of remaining suitable aquatic habitat would also be at risk for degradation related to sedimentation and contamination of aquatic habitats as well as additional fragmentation related to 30 miles of anticipated road construction. Suitable habitat in the Little Owl Research Natural Area would remain protected from most development impacts; however, plains topminnow has never been a documented species in the Little Owl Creek drainage. Although surface use would be stipulated, displacing surface use by 200 meters would not adequately protect suitable aquatic habitats from either sedimentation or contamination impacts (Entwistle and Nieves-Rivera 2014). Thus, the quantity and quality of 16.1 miles of suitable aquatic habitat has a high likelihood of degradation over 20 years of development and throughout the estimated 50 year production phase of an oil/gas well. Therefore, Alternative 2 is: **“Likely to result in a loss of viability in the Planning Area, or in a trend toward federal listing”** for the plains topminnow. Cumulative effects of Oil and Gas development on adjacent lands may result in degradation of suitable aquatic habitats and possibly extirpations from locally occupied habitats; however the full extent of those impacts are indeterminable.
 - Alternative 3 – No Surface Occupancy of Pawnee National Grassland. This alternative would also have few additional impacts to the either 4.5 miles of occupied or 16.1 miles (50%) of suitable aquatic habitat for the plains topminnow. Occupied aquatic habitat in South Pawnee Creek would remain protected from the anticipated impacts associated with Oil and Gas Development. Most occupied aquatic habitat in “Kibben Creek” (i.e., tributary to South Pawnee) and in West Willow Creek may remain at a high risk of degradation. Populations in these habitats are already at high risk of extirpation based on proximity of existing risks and minimal control over development on National Forest System Lands. The 3 miles of occupied aquatic habitat in South Pawnee Creek and 13.1 miles of additional suitable aquatic habitat may be subjected to some additional

fragmentation related to Forest Service permits for road access and pipelines; however, the agency will have more control over these permitted actions than well-drilling. Current populations and the capacity of suitable aquatic habitats to support plains topminnow would not be adversely affected. The likelihood that plains topminnow will remain a viable species on the PNG is moderate under this alternative. Therefore, Alternative 3 **“May adversely impact individuals, but not likely to result in a loss of viability in the Planning Area, nor cause a trend toward federal listing”** on the plains topminnow on the PNG. Cumulative effects of Oil and Gas development on adjacent lands may result in degradation of suitable aquatic habitats and possibly extirpations from locally occupied habitats; however the full extent of those impacts are indeterminable.

Management Indicator Species

The plains topminnow and northern plains killifish are Management Indicator Species for prairie aquatic habitats for the Pawnee National Grassland. These species have been documented to historically occur in most of the occupied aquatic habitats on the PNG. Based on the potential impacts that Oil and Gas Development may have on suitable and occupied aquatic habitats (refer to earlier portions of this chapter), population trends are likely to be affected by some of the alternatives. The following determinations have been made for the effects of Oil and Gas Development under the 3 management alternatives.

- Alternative 1 – No Additional Leasing of Federal Minerals. This alternative would have few additional impacts to 16.1 miles (~ 50%) of suitable aquatic habitat for the plains topminnow and northern plains killifish on the PNG. Aquatic habitat in South Pawnee Creek and Little Owl Creek would remain protected from the anticipated impacts associated with Oil and Gas Development. Aquatic habitat in “Kibben Creek” (i.e., tributary to South Pawnee), West Willow Creek, and Owl Creek may remain at a high risk of degradation because populations in these areas are already at high risk of extirpation based on proximity of existing risks and minimal control over development on National Forest System Lands. Habitat fragmentation is expected to be limited on 16 miles (~50%) of aquatic habitat in unleased mineral areas. Current populations and the capacity of suitable aquatic habitats to support plains topminnow and northern plains killifish would not be adversely affected. The likelihood that plains topminnow and northern plains killifish will remain a viable species on the PNG is moderate under this alternative. Therefore, Alternative 1 is expected to have a slightly negative effect on individuals of these species; however, this alternative would not result in a loss of species viability for either plains topminnow or northern plains killifish across the PNG.
- Alternative 2 – No Action, Development Under Forest Plan. This alternative is expected to result in additional long-term losses or reductions to 31 miles (~95%) of suitable aquatic habitat for plains topminnow and northern plains killifish. All suitable aquatic habitats would be at risk. In addition to the “at risk” occupied aquatic habitats in Willow and Kibben Creeks, habitats in South Pawnee Creek and the 16 miles of remaining suitable aquatic habitat would also be at risk for degradation related to sedimentation and contamination of aquatic habitats as well as additional fragmentation related to 30 miles of anticipated road construction. Although surface use would be stipulated, displacing surface use by 200 meters would not adequately protect suitable aquatic habitats from either sedimentation or contamination impacts (Entwistle and Nieves-Rivera 2014). Thus, the quantity and quality of all suitable aquatic habitat has a high likelihood of

degradation over 20 years of development and throughout the estimated 50 year production phase of an oil/gas well. Therefore, Alternative 2 is expected to have a negative effect on individuals and populations of both plains topminnow and northern plains killifish potentially leading to a loss of viability for species across the PNG.

- Alternative 3 – No Surface Occupancy of Pawnee National Grassland. This alternative would also have few additional impacts to 16.1 miles (~ 50%) of suitable aquatic habitat for the plains topminnow and northern plains killifish on the PNG. Aquatic habitat in South Pawnee Creek and Little Owl Creek would remain protected from the anticipated impacts associated with Oil and Gas Development. Aquatic habitat in “Kibben Creek” (i.e., tributary to South Pawnee), West Willow Creek, and Owl Creek may remain at a high risk of degradation because populations in these areas are already at high risk of extirpation based on proximity of existing risks and minimal control over development on National Forest System Lands. Habitat fragmentation is expected to be limited on 16 miles (~50%) of aquatic habitat in unleased mineral areas. Current populations and the capacity of suitable aquatic habitats to support plains topminnow and northern plains killifish would not be adversely affected. The likelihood that plains topminnow and northern plains killifish will remain a viable species on the PNG is moderate under this alternative. Therefore, Alternative 1 is expected to have a slightly negative effect on individuals of these species; however, this alternative would not result in a loss of species viability for either plains topminnow or northern plains killifish across the PNG.

3.9 Wildlife Species and Habitats

3.9.1 Affected Environment

Wildlife on the Pawnee National Grassland (PNG) is diverse. A total of 59 mammal species, 8 amphibian species, 14 reptile species, 13 fish species, and 301 species of birds are known to use the Grassland for all or a part of their habitat. This diversity of wildlife is due in part to the diversity of habitats found on the Grassland. The location of the Grassland in relation to the Rocky Mountains and the Great Plains, as well as its proximity to avian migration corridors, and flyways also influences the diversity of wildlife found here.

Many of the common wildlife species that occur on the Grassland are associated with short grass prairie ecosystems and use prairie dog colonies to meet a variety of their needs. Some of the most common mammal species include pronghorn antelope, American badger, coyote, striped skunk, deer mouse, thirteen-lined ground squirrel, black-tailed jack rabbit, and eastern cottontail. Common bird species associated with prairie dog towns include eastern meadowlark, golden eagle, American kestrel, horned lark, killdeer, and western meadowlark. Common reptiles and amphibians include prairie rattlesnakes, Texas horned lizards, Wood house’s toad, Plains spade foot toad, and tiger salamanders.

Black-tailed prairie dogs have been called a “keystone” species, a foundation species, and a highly interactive species by authors, based on its pronounced impact on the grassland ecosystem and its role in grazing, burrowing, and as a prey species. Many species depend on prairie dogs as

prey and still more depend on prairie dog burrows for shelter. Others depend on prairie dogs to create and maintain open habitats. Sharps and Uresk (1990), state that 134 vertebrate species have been documented on prairie dog towns. Many of these occur on the PNG.

The analysis area serves as pronghorn habitat. This species is a game species and numbers are managed by the CPW. The entire PNG serves as fawning habitat (CPW 2011).

The PNG is also known for its raptors. The Pawnee Buttes is visited by the public, as historically the area supported several raptor nest sites. Golden eagles, ferruginous hawks and prairie falcons historically nested at the Buttes. In 2012 and 2013 there was one known prairie falcon nest site. Golden eagle and ferruginous hawk numbers have drastically decreased in the past 20 years, based on annual monitoring. The ferruginous hawk resides on the PNG year round. The rough legged hawk inhabits the grassland during the winter months. It nests in the northern part of North America. The Swainson's hawk is a summer resident and the most common nesting hawk. American kestrels, an occasional red tail hawk, and great-horned owls also nest on the PNG. It is a Forest Plan standard to protect raptor nest sites.

Conversion of native grasslands to agricultural cropland and urban development has altered the look and character of the short grass prairie region. This alteration and fragmentation of the landscape has changed the level of wildlife diversity the vast landscape once supported. Concern has grown over the past several years for the long-term sustainability, diversity, and integrity of many components of the short grass prairie grassland ecosystem as a whole (Grassland Species). Grasslands are one of the most threatened ecosystems on the planet (Steidel et. al. 2013)

Species Considered and Evaluated

Threatened and Endangered Species

An analysis was conducted per Forest Service Policy on Threatened, Endangered, Sensitive and MIS species who may be impacted by the proposed project. The Endangered Species Act of 1973 (as amended) requires all federal departments and agencies to conserve Threatened and Endangered species and the habitats on which they depend, and to consult with the U.S. Fish and Wildlife Service on all actions authorized, funded, or carried out by the agency to ensure that the actions will not likely jeopardize the continued existence of any Threatened and Endangered species or adversely modify critical habitat (FSM 2670; USFS 2005). The Forest Plan also identifies species of viability concern on the Forest and species for which additional baseline information is needed to determine viability status.

Table 36 Threatened and Endangered Species Considered in this Analysis

Common Name	Species	Status	Species Excluded from Further Analysis	Reason for Exclusion
Piping Plover	<i>Charadius melodus</i>	Threatened	N	

Least Tern	<i>Sterna antillarum</i>	Endangered	N	
Mexican spotted owl	(<i>Strix occidentalis lucida</i>)	Threatened	Y	No habitat
Whooping Crane	<i>Grus Americana</i>	Endangered	N	
Preble's Meadow Jumping Mouse	(<i>Zapus hudsonius preblei</i>)	Threatened	Y	No habitat

Sensitive Species

In addition, the Forest Service requires a biological evaluation of effects on species proposed for federal listing as Threatened or Endangered, and Forest Service Sensitive species and habitat (FSM 2672.4; USFS 2009). Sensitive Species are identified by the Forest Service Regional Forester as "those...for which population viability is a concern, as evidenced by...significant current or predicted downward trends in population numbers or density..." or "significant current or predicted downward trends in habitat capability that would reduce a species' existing distribution." (FSM 2670.5; USFS 2005). A biological evaluation is necessary to ensure that Forest Service actions do not contribute to loss of viability of any Threatened, Endangered, Proposed, or Sensitive plant or animal species, or cause any species to move toward federal listing. The biological evaluation is also used to identify opportunities for species and habitat enhancement and to reduce potential negative impacts.

The analysis of effects on wildlife species, including Threatened, Endangered, Proposed, Sensitive, Management Indicator, and Species of Viability Concern (collectively referred to as "special status species"). The quality and quantity of habitat is considered in the analysis (USDA 1981).

Table 37 Sensitive Species Considered in this Analysis

COMMON NAME	SPECIES	SPECIES EXCLUDED FROM FURTHER ANALYSIS	REASON FOR EXCLUSION
Mammals			
Mammals			
Black-tailed prairie dog	<i>Cynomys ludovicianus</i>	No	
Fringed myotis	<i>Myotis thysanodes</i>	No	
Swift fox	<i>Vulpes velox</i>	No	
Birds			
American bittern	<i>Botaurus lentiginosus</i>	No	
Bald Eagle	<i>Haliaeetus leucocephalus</i>	Yes	Rare migrant on the PNG. No species or habitat within the project area.
Black tern	<i>Chilidonias niger</i>	No	

COMMON NAME	SPECIES	SPECIES EXCLUDED FROM FURTHER ANALYSIS	REASON FOR EXCLUSION
Brewer's sparrow	<i>Spizella breweri</i>	No	
Burrowing owl	<i>Athene cunicularia</i>	No	
Cassin's sparrow	<i>Aimophila cassini</i>	No	
Chestnut-collared longspur	<i>Calcarius ornatus</i>	No	
Ferruginous hawk	<i>Buteo regalis</i>	No	
Grasshopper sparrow	<i>Ammodramus savannarum</i>	No	
Lewis' woodpecker	<i>Melanerpes lewis</i>	No	
Loggerhead shrike	<i>Lanius ludovicianus</i>	No	
Long-billed curlew	<i>Numenius americanus</i>	No	
McCown's longspur	<i>Calcarius mccownii</i>	No	
Mountain Plover	<i>Charadrius montanus</i>	No	
Northern harrier	<i>Circus cyaneus</i>	No	
Olive-sided flycatcher	<i>Contopus cooperi</i>	Yes	Resides in pine trees of interior forest
Peregrine falcon	<i>Falco peregrinus</i>	Yes	Rare migrant on the PNG. No species or habitat within the project area.
Purple martin	<i>Progne subis</i>	Yes	Rare migrant on the PNG. No primary habitat (aspen) present.
Yellow-billed cuckoo	<i>Coccyzus americanus occidentalis</i>	No	
Amphibians			
Northern leopard frog	<i>Rana pipiens</i>	No	
Invertebrates			
Regal fritillary butterfly	<i>Speyeria idalia</i>	No	

The Forest Plan identifies management indicator species (MIS) as a way to monitor wildlife population changes on the Grassland. Management indicator species are wildlife species that have been selected by a National Forest and Grassland to represent the habitat needs of a larger group of species requiring similar habitat communities and that are likely to reflect changes in habitat conditions. MIS are also chosen to address a significant issue on the National Grassland.

Management Indicator Species and Sensitive Species Analyzed Fully in the EIS

For this EIS, Management Indicator Species (MIS) and those sensitive species considered to be most at risk from the indirect impacts of the Leasing Decision were chosen for a detailed analysis.

The analysis area considered for this project includes the lands administratively available for oil and gas leasing in the administrative boundaries of the Pawnee National Grassland (PNG). Acres of habitat were calculated based on the species habitat within cumulative impact analysis areas. For most species, the administrative boundary of the PNG was determined to be adequate in size. For species such as the swift fox, and mountain plover, whose habitat use occurs in between and beyond the boundaries of the PNG, an impact analysis area extended beyond the administrative boundaries. For more information on the analysis area rationale refer to the wildlife project files. Below is a table with their status, and acres of habitat for the species analyzed.

Table 38 Potential Acres by Species in Wildlife Analysis Area

Species	Habitat description	Forest Service Species Designation	Management Indicator Community	Potential Habitat Acres in wildlife analysis area (includes private lands)	Acres of PNG habitat
*Mountain Plover	Loamy plains and 5% or less slope	MIS and Sensitive	Short grass prairie	874,559	121,453
*Swift fox	Short grass prairie, agricultural pastures on PVT	Sensitive	N/A	1,250,714	175,394
Black-tailed Prairie Dog	Prairie dog burrows	MIS and Sensitive	Prairie dog towns	132,080	42,499
Western Burrowing Owl	Prairie dog burrows	MIS and Sensitive	Prairie dog towns	132,080	42,499
Ferruginous Hawk	Primarily Trees, occasional use of cliff sites, ground for nesting. Foraging.	MIS and Sensitive	Short grass and mid grass prairie	N/A	158,572
Northern Leopard frog	Wetlands, ponds.	Sensitive	N/A	Approximately 33 miles of stream	Approximately 33 miles of stream, 9 occupied sites
Lark bunting	Mid to tall grass prairie	MIS	Mid to tall grass prairie	N/A	11,067
Mule Deer	Prairie woodlands	MIS	Prairie woodlands	N/A	1,339

*analysis area extends beyond oil/gas EIS analysis area boundary due to species' range

Methodology

Potential effects to wildlife were assessed by considering 1) life history requirements, 2) species' occurrence, where known 3) assessing known impacts from both existing oil and gas development activities as well as other actions which have similar effects to wildlife and wildlife habitats. Key indicators for these impacts are described below. 4) Applying the Reasonable Foreseeable Development (RFDS) Scenario to species' habitat. The RFDS projection was applied to species' habitat in order to display the greatest level of potential effects if all development were to occur within a species' habitat. Potential impacts are described broadly because the site specific locations of future oil and gas development are unknown.

The acres of land disturbance and road miles are based on the Reasonably Foreseeable Development (RFD). The RFD predicts that approximately 80 well pads, totaling 960 acres of disturbance may occur on the PNG during the construction phase. In the short-term (less than 1 year) a typical well pad will disturb 12 total acres (10 acres for the well pad, 1 acre for the road, and 1 acre for the pipeline).

In the long term (after 1 year) a typical well pad will disturb 1.5 acres (1 acre for the pad, .5 acres for the road, and zero for the pipeline—because it's buried underground). Total road miles for all 80 wells were calculated at 30 miles This is derived from approximately .3 miles of road per well pad (80 well pads) (White 2014).

Because it is not known where the well pads would occur, an assumption was made by the interdisciplinary team that some of the well pads would occur on the unleased lands, while others would occur on the already leased lands or private minerals with federal surface ownership on the PNG.

For analysis sake, it was assumed that the percentage of well pads and their associated acreage would occur based on the percentage of lands on each of the three types of minerals estates occurring on the PNG. Below is a table depicting this break out of acreage and road miles by mineral estate. These calculations are used throughout the analysis and applied to the species' habitat.

Table 39 Acres of Land Disturbance during Construction and Reclamation Stage and Road Miles Based on 960 acres of well pads and 30 miles of Road

Mineral Estate and Approximate Acres of PNG Land	% of PNG land in each Mineral Estate	Approximate number of well pads analyzed (total = 80)	Approximate Acres Impacted during Construction Phase (alternative 2 and 3)* (12 acres per well pad)	Approximate Acres Impacted After Reclamation (1.5 acres per well pad)	Approximate Road Miles (based on 30 miles of road total)
Unleased 100,329 acres	53%	42	(53% of 960 acres)= 508 acres	(42 well pads X 1.5 acres) = 60 acres	(53% of 30 miles)= 16 miles

Leased 43,444 acres	23%	18-19	(23% of 960 acres)= 221 acres	19 well pads X 1.5 = 29 acres	(23% of 30 miles = 6.9 miles
Private Minerals 43,444 acres	24%	20	(24% of 960 acres)= 231 acres	20 well pad X 1.5 acres = 30 acres	(24% of 30 miles = 7.2 miles

*Alternative 1 would be approximately 10% more well pads and roads than under alternative 2 or 3. This is due to the fact that PNG lands would be avoided, and avoiding the lands would result in more well pads. Refer to the EIS, Chapter 2, for more clarification of Alternative one. Therefore, 46 well pads were analyzed (10% additional to the 40 well pads), and 10% more acres, resulting in approximately 539 acres of disturbance. Reclamation would result in approximately 63 acres of disturbance from well pads and roads long term. There would be approximately 10% more roads (compared to 16 mile of unleased lands under alternative 2 or 3), resulting in 17 miles of road that is analyzed in the indirect effects.

Terrestrial Wildlife Key Indicators and Evaluation Measures

Indirect effects to wildlife that may occur once a parcel of the Pawnee National Grassland is leased and subsequently developed for oil and gas production can be categorized into two broad relevant issues: behavioral disturbance impacts and physical impacts. Key indicators were developed to help focus the oil and gas potential future development effects analysis on priority issues for wildlife. These are listed below along with appropriate measures for evaluating each key indicator.

Table 40 Terrestrial Key Indicators and Evaluation Measures

Identified issue	Indicator
Terrestrial Wildlife Issue Statement (Physical) Potential future development of oil and gas leases could result in physical impacts to terrestrial wildlife habitats and movement corridors including habitat loss, habitat degradation, mortality, interruption of wildlife movement corridors, and isolation)	Percent of habitat lost or substantially degraded as compared to available habitat (calculation) Habitat fragmentation –narrative discussion Increase in invasive plants (Narrative Discussion)
Terrestrial Wildlife Issue Statement (Behavioral) Potential future development of oil and gas leases could result in behavioral disturbance, impacts or mortality to terrestrial wildlife species due to oil and gas development, and production activities associated with road use, noise, and night time lighting.	Human presence and noise (narrative) Road density/miles of road (calculation) # of visits with traffic (calculation) noise level (narrative)

3.9.2 Environmental Consequences

Federally listed species

Within the programmatic oil and gas leasing decision, the whooping crane, piping plover, and least term species would only be affected by downstream water depletions in the South Platte Basin. The leasing decision alone will not cause additional water depletions. Rather, water depletions would occur at the site-specific scale (i.e., Application Permit to Drill), when wells would be authorized to be developed. In context of the programmatic leasing decision, water depletions have been cumulatively summed based on the RFD (Reasonable Foreseeable Development) scenario and the forecasted effects determination has been provided for the leasing alternatives. Existing leases are anticipated to cause a 6375 ac-ft of water depletions from the South Platte River. Under the No Leasing alternative, it is likely that there would be collectively fewer wells and thus less water needed for the development of oil and gas resources; however, most water used for well-drilling, development, and production would occur on adjacent private lands. It is not determinable how much water would be used to development infrastructure on adjacent lands, but it is reasonable to assume that less water would be depleted from the South Platte Basin under the No Leasing alternative compared to others. Additional leases under the No Action alternative would result in additional water depletions subject to Section 7 ESA consultation. Based on the RFD and assumptions of development, the forecasted amount of additional water depletions to the South Platte River would be approximately 7140 ac-ft to be consulted upon during the site-specific analysis. Under the No Surface Occupancy alternative, additional well pad development, well drilling, and most of other activities associated with water depletions would not occur on lands administered by the Pawnee National Grassland. Oil and gas infrastructure that would have been developed on PNG would be displaced to adjacent lands and thus, the forecasted water depletion for the South Platte assumed for the No Action alternative, 7140 ac-ft, would also occur, albeit on surface ownerships that may or may not be subject to Section 7 ESA consultation for downstream water depletions.

Under those forecasted water depletions, both the No Action Alternative (No. 2) and No Surface Occupancy Alternative (No. 3) would eventually lead to similar amounts of water depleted from the South Platte Basin. The No Leasing Alternative (No. 1) is not expected to increase the amount of water depleted from the South Platte Basin.

- Alternative 1 – No Additional Leasing of Federal Minerals. This alternative would have “no effect” on Pallid Sturgeon because without O&G development (e.g., drilling, hydro-fracturing) there would not be a large demand for water and thus no additional water depletions as related to this leasing decision. It is undeterminable how much water might be used or needed for any road construction related to O&G development occurring on adjacent lands.
- Alternative 2 – No Action, Development Under Forest Plan. This alternative is expected to result in 7,140 ac-ft of new water depletions largely from sources in the South Platte Basin. We anticipate that most of these water depletions would have a federal nexus for proponents. These water depletions exceed the de minimus that the U.S. Fish & Wildlife Service established in 2006 (U.S. Fish & Wildlife Service Biological Opinion 2006). Depletions exceeding the de minimus adversely affect species dependent on the Platte River Ecosystem, therefore the No Action alternative **“may affect and is likely to adversely affect”** the whooping crane, piping plover, and least tern,
- Alternative 3 – No Surface Occupancy. This alternative is also expected to result in 7,140 ac-ft of new water depletions largely from sources in the South Platte Basin. Many

of these water depletions would likely have a federal nexus for proponents due to connectedness of the federal mineral estate as accessed via adjacent non-federal lands. These water depletions exceed the de minimus that the U.S. Fish & Wildlife Service established in 2006 (U.S. Fish & Wildlife Service Biological Opinion 2006). Depletions exceeding the de minimus adversely affect species dependent on the Platte River Ecosystem, therefore the No Surface Occupancy alternative “**may affect and is likely to adversely affect**” the whooping crane, piping plover, and least tern.

Sensitive and Management Indicator Species Effects

Physical Disturbance Impacts

Potential future development of oil and gas leases has the potential to physically impact terrestrial wildlife habitats and movement corridors. Physical impacts may include

- habitat loss,
- habitat degradation,
- habitat fragmentation and isolation,
- and interruption of wildlife movement corridors (USDA unpublished).

The loss, removal, or fragmentation of vegetation and habitat structure influences wildlife by reducing quality, quantity, extent, and/or availability of resources for critical life requirements. Critical life requirements include food, cover, water, and space needed for survival, growth, reproduction, and protection from predators and weather. Refer to the wildlife species’ effects analysis for % habitat loss by species.

Although the actual physical footprints of well pads, associated facilities, pipelines and access roads do not result in large amounts of direct habitat loss, the presence of oil and gas development can result in considerable effects to wildlife in some areas. In general, an increase in people and human development can degrade wildlife habitat and change wildlife movement patterns (USDA 2012). Refer to the behavioral disturbance impact section for more information.

The loss or substantial degradation of habitats can modify wildlife occurrence, abundance, and distribution at local scales, and potentially influence wildlife at larger landscape levels. In addition to the physical impacts that may be caused by the potential future construction of oil and gas facilities, impacts to wildlife habitats could result from the potential construction of new roads to access oil and gas development areas. Additional physical impacts associated with oil and gas development and production activities may include unintentional wildlife mortality resulting from collisions with wildlife along access roads, entrapment in open vertical pipes and vents, drowning, poisoning, or hyperthermia from contaminated water sources (such as reserve pits, oil field waste pits, ponds and tanks, and wastewater disposal facilities. (USDA 2012).

Habitat fragmentation has the potential to isolate small populations, contribute to decreased population distribution, and contribute to the increased likelihood of local extinction. This may occur naturally through such agents as fire, landslides, wind throw, and insect attack. On managed lands, human-related activities (e.g., timber harvesting, oil/gas development, resource extraction, and road construction) have been the dominant disturbance agents (USDA Sioux

2012- Custer National Forest). For larger mammals, fragmentation may hinder metapopulation dynamics such as migration and dispersal. At a smaller scale, wildlife such as small mammals and reptiles are affected by single roads that may split a population in half and prevent migration in and out. Fragmentation of fish and wildlife populations leads to reduced genetic diversity and increased susceptibility to population decline. This is particularly true for migratory species that habitually move long distances (USDA 2014, USDA 2012a- Custer National Forest).

Roads are a major source of habitat fragmentation. Roads also contribute to impacts such as barriers to movement of wildlife; and can isolate rare and unique habitats, or intersect habitats such as riparian areas. Overall, the physical effect of road corridors (in the absence of human use) has the most adverse effect on wildlife when 1) the road is wide 2) is constructed in remote, undisturbed habitat 3) divides limited habitat essential to small animals or separates resources needed within the annual home range (Meadows 2002). Larger animals may also cross roads less than expected (Mace et al. 1996; Krebs and Lewis 1997), though this may be related more to avoiding traffic and noise than to the physical presence of the road. The barrier effect also varies with the size of the road and the level of traffic. Roads also are sites of human disturbance, which will be addressed further in the document (USDA 2014).

Roads act as common vectors for the introduction of noxious weeds and non-native plants, wildlife, and diseases. These noxious weeds and non-native species and diseases can lead to habitat degradation, competition with native species, and potentially reduced survival of native species. The creation of well pads also increases noxious weeds through disturbance to soil and increases the risk of heavy equipment from other areas bringing in new noxious weed seeds. Invasive plants usually deplete soil and water resources more quickly and aggressively than native plants, thus out-competing them, and reducing the diversity of the vegetation, which tends to diminish the value of wildlife habitats in general.

Roads are a primary, chronic source of sedimentation for aquatic, wetland, and riparian habitats. Increased sedimentation in water sources can result in the following: stream bank instability, channel widening and straightening, decreased water depths, changes to water flows, reduced dissolved oxygen capacity, loss of invertebrate and fish spawning habitats, filling of pools, and changes to water temperatures.

New road construction would provide increased access to remote wildlife habitat areas by both oil and gas personnel and possibly other users. Pipelines supporting oil and gas activities that may be constructed cross-country outside of road right of ways would also result in physical impacts to wildlife habitat. Pipeline corridors could be re-vegetated within a few years. Pipelines would contribute to the fragmentation of wildlife habitats but would not be expected to deter wildlife movements for the long term.

Possible future development of oil and gas resources has the potential to negatively affect water quality and quantity in creeks, ponds, wetlands, playas and springs. Construction and use of roads and well pads can result in erosion of soils, some of which may reach water sources. Chemical water quality can be affected by spills and leaks of industrial chemicals and drilling fluids used in the drilling and finishing processes (USDA 2012). Pipelines can leak, causing contamination to the ground and wildlife habitat. For more information on the impacts to water quality and aquatic habitats, see the Hydrology Section.

Behavioral Disturbance Impacts

Potential future development of oil and gas leases could cause behavioral disturbance impacts to terrestrial wildlife. Behavioral disturbances in wildlife may include:

- Changes in use of habitats
- Changes in use of movement corridors
- Changes in behavior
- Physiological reactions to stress (especially during critical time periods such as winter and reproduction periods) (USDA 2012).
 - Mortality

The behavioral disturbances listed above could be caused by any of the following:

- Presence of people
- Vehicle and equipment noise
- Construction activities
- Lights from drill rigs, vehicles, and facilities
- Increased vehicle traffic

These oil and gas activities may lead to displacement of individuals from preferred habitats to areas that are less desirable. They may also result in a change in use of wildlife travel routes and movement patterns. Ultimately, behavioral disturbances could lead to avoidance of habitats.

Behavioral impacts may in turn lead to increased vulnerability to mortality through predation, energy expenditure in winter, and loss of critical food or water resources. Physiological reactions to stress and reduced nutrition can also lead to reductions in reproductive success or survival (Joslin and Youmans 1999; Knight and Gutzwiller 1995; Olliff et al. 1999; USDA Forest Service 2000; Wisdom et al. 2004).

Behavioral disturbance impacts of road use have been documented in many wildlife species. The widespread detrimental impacts of human disturbance on wildlife, fish, and plant communities are well documented throughout these reports. No positive benefits to native species of wildlife, fish, or rare plants have been identified from increases in road and trail access. Direct and indirect effects on species that have been identified in the literature indicate negative impacts to all studied species as motorized, mechanized, and other travel uses increase.

Roads and trails allow increased human intrusion into wildlife habitats. Disturbance by humans and vehicles on roads and trails make habitats less secure for wildlife (USDA 2012). In addition, increased humans can lead to higher mortality risk from increased collisions

intentional or unintentional harassment, poaching and increased harvest levels by legal hunting (USDA 2014, Lyon 1983).

The use of roads to access oil and gas sites has a high potential to impact wildlife species along these corridors. There is high potential for impacts, because the potential future development and operation of oil and gas activities include many visual and noise producing sources. These sources include:

- Large and potentially noisy vehicles and facilities
- High frequency road use (traffic)
- Day and night operations (24 hours)

Potential future oil and gas development is also anticipated to result in new road construction to access development sites. An increase in road density would result in a reduction of wildlife habitat effectiveness. Researchers found the type and magnitude of human disturbance impacts on wildlife varies depending on many factors. These factors include the type of activity; predictability, frequency and magnitude; time of day or season of year; and location of the disturbance (Knight and Gutzwiller 1995).

Traffic volume is especially important when evaluating road impacts to wildlife. Jaeger et al. 2005, found that although vulnerability to traffic varied among species, traffic volume had the greatest effect on population persistence. Traffic also had the greatest impacts in largely undisturbed areas (Charry Jones 2009). Vehicle traffic both day and night could result in mortalities to wildlife by vehicle collisions and potential for wildlife poaching (USDA 2012).

The scientific literature contains a number of studies on the effects of roads and oil and gas activities on wildlife. A couple particularly relevant studies are summarized below. When reviewing these studies, however, it is important to note that the term “avoidance” as used in these articles does not mean total avoidance, but instead refers to disproportionately low use based on the type or extent of habitat present.

For lesser prairie-chicken, Pittman (2005) determined that they avoided nesting for 80 meters (wellheads) to greater than 1,000 meters (buildings) from wellheads, buildings, improved roads, transmission lines, and center-pivot irrigation fields in sand-sagebrush habitat.

More recently, during a 10-year study of mule deer habitat use prior to and during the development of the Pinedale gas field in southwestern Wyoming, Sawyer and Nielson (2010) reported that deer consistently avoided habitat within 2.5 to 3.5 kilometers from well pads, although this habitat was of high use prior to development. Sawyer and Nielson also found that mule deer abundance was 60 percent lower in 2009 compared to 2001 within the study area while abundance was increasing in the reference area.

Reed et al. (1996) calculated that the effective habitat loss associated with construction of new roads in an area open to logging was 2.5 to 3.5 times the actual habitat loss, assuming a “road-effect” zone extending 100 meters from a road.

Bird communities changed in response to noise at well pads. Species diversity decreased, nest site locations changed, and predation of some species’ nests were lessened due to a reduction of predatory birds (Francis, C.P. Ortega and A. Cruz 2009).

Ingelfinger (2001) reported that numbers of sagebrush steppe songbirds are reduced by up to 60 percent within 100 meters of high-traffic roads (greater than 12 vehicles per day) associated with oil and gas development and by up to 50 percent within 100 meters of low-traffic roads.

Studies of the effects of human disturbance on wildlife have revealed there are critical periods for many bird and mammal species when disturbance can result in more serious impacts (Knight and Gutzwiller 1995). The immediate postnatal period for mammals and the breeding period for birds are often the most sensitive. The impacts would be greatest in these areas during periods of critical wildlife use such as reproduction seasons and winter months when species survival is most difficult. (USDA 2012). Areas such as pronghorn fawning areas, raptor nest sites, and prairie dog towns are areas of concern.

Below is a table depicting road densities by mile per square mile in the PNG analysis area by alternative for unleased lands. When considering the impacts of indirect impacts of **unleased lands**, under alternative 1, **there would be approximately 17 miles of road on private lands**. This increase accounts for approximately 10% more well pads. **Under alternative 2, there would be approximately 16 miles additional roads to access well pads. Under alternative 3, there would be approximately 16 miles of road**, with the majority being built on private lands. Therefore, under alternative 1 and 4 there would be no increase in road densities on PNG lands unless exceptions were granted to the lease stipulation of NSO. Alternatives 1 and 3 would also result in more secure areas for wildlife and less fragmentation on the PNG lands. Of the three alternatives, impacts to wildlife fragmentation and other behavioral impacts described above would be least under alternative 3. At road densities of over 2 mile/square mile, surrounding habitat for large mammal species is considered to be reduced by at least 50% (WildEarth Guardians 2006). Adding in the additional miles of road, as displayed below, increases the road density by a negligible amount.

Table 41 Total Road Density within the PNG Administrative Boundary by Alternative

	Existing Condition road density miles/square mile)	Alternative 1 miles /square mile (addition of 17 miles of road on private land) road	Alternative 2 miles /square mile of road (addition of 16 miles of road on PNG land)	Alternative 3 (addition of 16 miles of road on private land)
	1.74	1.76	1.76	1.76

Summary of Comparison of Alternatives by Indicator

The table below summarizes impact determinations to species analyzed for this project based on physical and behavioral indicators. For more information, refer to species effects analysis in Chapter 3 of the EIS or BE. The table below was used as a way to compare alternatives by

indicator on the PNG. For wildlife these indicators are behavioral and physical indicators and are discussed above.

Table 42 Comparison of Indicators by Alternative.

Indicators	Alternative 1- no additional leasing	Alternative 2- No action Forest Plan	Alternative 3 NSO
Habitat loss	Negligible	Moderate adverse	Negligible
Habitat fragmentation	Minor adverse	Moderate adverse	Minor adverse
Human presence and disturbance	Moderate * adverse	Moderate adverse	Moderate adverse
Road density	Negligible	Negligible	Negligible
# of traffic visits	Moderate adverse	Moderate adverse	Moderate adverse
Increase in invasive plants	Minor adverse	Moderate adverse	Minor adverse

* construction phase for all determinations. Impacts for human disturbance and # traffic visits would decrease during the production phase.

In some cases, impacts to individual's species may vary from the above table. The table depicts an overall summary to compare the wildlife indicators analyzed between the alternatives and focusing on impacts on PNG lands. It does not include the cumulative impacts of additional drilling that is occurring on private lands beyond the 80 well pads analyzed in this EIS. In some cases, combined with the cumulative impacts on private, there could be a more noticeable impact, such as moderate to major adverse for indicators such as habitat fragmentation or traffic.

Habitat loss and fragmentation would not occur on PNG lands under alternatives 1 and 3. The no leasing alternative and the NSO would reduce and/or avoid impacts to wildlife. Large areas of unfragmented land equaling about 1000,00 acres would remain on the PNG. To further clarify, under all alternatives, impacts such as human presence and traffic from well pads built on private lands can impact wildlife residing on the PNG. This is because although well pads are placed on private lands, wildlife species use both private and PNG land. Also, the unique situation of the mixed land ownership pattern on the PNG causes indicators such

as traffic and human disturbance to occur adjacent to PNG lands and therefore still impacts wildlife within the boundaries of the federal PNG lands. One disadvantage of alternative 1 and 3 is that site specific design measures at well pad sites such as for noise, and perch inhibitors to lessen impacts cannot be designed at the APD stage, as in alternative 2. Well pad design would occur under the COGC (Colorado Oil and Gas Commission) regulations. Under alternative 2, there is the possibility of implementing section b of the standard lease term form. This section allows for measures to reduce impacts to sensitive species including prairie dogs to reduce adverse impacts to the prairie dog. A more site specific analysis at the APD stage would need to occur to determine the level of impact.

Overall, alternative 2 is the most impacting alternative, with alternative 1 being intermediate in impacts. The 10% increase in roads and well pads under alternative 1 would be more impacting than under alternative 3, but 10% was not measureable enough to distinguish a difference in impact determinations used above. Because there would be less well pads and roads under alternative 3 than alternative 1 and well pads and associated roads would not occur on the PNG, alternative 3 is the least impacting alternative for wildlife.

Effects to Sensitive Species

The following sensitive species may occur in the project area and may be impacted by the proposed project: the fringed myotis, American bittern, black tern, Long-billed curlew, Yellow-billed curlew, brewer's sparrow, Cassin's sparrow, chestnut-collared longspur, grasshopper sparrow, Lewis's woodpecker, loggerhead shrike, McGowan's long spur, regal fritillary butterfly, and Northern harrier

Under alternative 2 there would be a minor to moderate loss of habitat with the construction of 80 well pads resulting in 960 acres of habitat loss if all well pads occurred in any one species' habitat. During the construction phase, there would be a loss of habitat of approximately 60 acres. It is not known at this time where well pads would be placed. Site specific impacts would need to occur at the APD stage. Timing stipulations for the mountain plover of April 10-July 10 would reduce impacts of bird species relying on similar nesting habitat to the mountain plover such as the long-billed curlew, McGowan's longspur, and loggerhead shrike.

Under alternative 1 and 3, there would be no loss of habitat on the PNG for any of the sensitive species listed above. Habitat loss and increased fragmentation would occur on private lands. Fragmentation and habitat loss would be the least under alternative 3 because there would be about 10% less roads and well pads built compared to alternative 1. Well pads may be built adjacent to PNG habitat of these species during the nesting season under alternatives 1 and 3.

Under all alternatives, increased traffic would occur at the level of over 300,000 vehicle trips if all 80 well pads were constructed at the same time. This would be an unlikely occurrence. For about 50 years (the life of the well) there would be approximately 2 one way vehicle trips per day to the well pads. The increased traffic would likely increase the risk of mortality by vehicles to all sensitive species. Under all alternatives, there would be an increase in road density with the addition of about 16 miles of road under alternatives 2 and 3, and 17 miles of road under alternative 1. This increase in road density compared to the overall road density discussed above is a minor to moderate effect. Human disturbance for several months at one well pad may occur under all alternatives adjacent to or on the PNG. This may result in species' avoiding portions of the PNG due to human disturbance and noise. The impacts of roads would be greatest under alternative 2 because there would be increased fragmentation, especially on important habitats such as prairie dog towns or near aquatic habitat. Fragmentation of the grassland as a whole, including private lands would occur. Increased noxious weeds would likely occur as a result of well pad construction. This increase in noxious weeds would be most detrimental under alternative 2, because noxious weeds could occur along road sides at well pads. Conditions of approval for noxious weed treatment could occur under alternative 2. Noxious weeds may also increase under alternatives 1 and 3, with three being the least impacting because less well pads and roads would be built than under alternative 1.

In consideration of these impacts, the loss of habitat is minor (< 1 % of the Pawnee) and fragmentation under all alternatives would not substantially increase based on road densities discussed above. Several of these species have not occurred on the PNG more than occasionally and have limited amounts of habitat. This reduces the likelihood of impacts. Some of these species include the yellow billed cuckoo, long billed curlew, American bittern, regal fritillary butterfly and black tern. Some of the species have abundant habitat on the grassland, such as the McGowan's long spur. Based on previous analyses of several species utilizing similar habitat, and considering the impact of oil/gas activities on these species, and the likelihood of occurrence, under all alternatives, this project may adversely impact individuals but is not likely to cause a loss of viability in the planning area or cause a trend towards federal listing for the following species: the fringed myotis, American bittern, black tern, Long-billed curlew, Yellow-billed curlew, brewer's sparrow, Cassin's sparrow, chestnut-collared longspur, grasshopper sparrow, Lewis's woodpecker, loggerhead shrike, McGowan's long spur, regal fritillary butterfly, and Northern harrier

The table below includes a summary of the impact determinations to sensitive wildlife species by alternative

Table 43 Summary of Impact Determinations To Sensitive Wildlife Species

COMMON NAME	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
Black-tailed prairie dog	MII	MII	MII
Fringed myotis	MII	MII	MII
Swift fox	MII	MII	MII

COMMON NAME	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
American bittern	MII	MII	MII
Black tern	MII	MII	MII
Brewer's sparrow	MII	MII	MII
Northern Burrowing owl	MII	MII	MII
Cassin's sparrow	MII	MII	MII
Chestnut-collared longspur	MII	MII	MII
Ferruginous hawk	MII	MII	MII
Grasshopper sparrow	MII	MII	MII
Lewis' woodpecker	MII	MII	MII
Loggerhead shrike	MII	MII	MII
Long-billed curlew	MII	MII	MII
McCown's longspur	MII	MII	MII
Mountain Plover	MII	MII	MII
Northern harrier	MII	MII	MII
Yellow - billed cuckoo	MII	MII	MII
Northern leopard frog	MII	WLRLV	MII
Regal fritillary butterfly	MII	MII	MII

MII: may impact individuals but is not likely to result in a loss of viability in the planning area or cause a trend in federal listing.

The majority of the Management Indicator Species analyzed are sensitive species. The analysis for these species is discussed previously. The mule deer and lark bunting are MIS species that are not sensitive species.

Table 44 Summary of Determinations for MIS species

MIS Species	Alternative 1	Alternative 2	Alternative 3
Mountain Plover	Neutral influence on habitat and neutral impact on local population	Neutral influence on habitat and neutral influence on local population	Neutral influence on habitat and neutral impact on local population
Northern Burrowing	Neutral influence	Negative	Neutral influence

Owl	on habitat and negative influence on local population	influence on habitat negative influence on local population	on habitat and negative influence on local population
Black-tailed prairie dog	Neutral influence on habitat and neutral influence on local population	Negative influence on habitat and negative influence on local population	Neutral influence on habitat and negative influence on local population
Ferruginous hawk	Negative influence on habitat and negative impact on local population	Negative influence on habitat and negative influence on local population	Negative influence on habitat and negative influence on local population
Mule Deer	Negative influence on habitat and negative influence on local population	Negative influence on habitat and negative influence on local population	Negative influence on habitat and negative influence on local population
Lark Bunting	Neutral influence on habitat, negative influence on population	Negative influence on habitat and negative influence on local population	Neutral influence on habitat and negative influence on local population

3.10 Air Quality

Legal Framework

The Forest Service manages lands in accordance with Congressional direction in the form of legislation. There are several important laws affecting the way the service protects air quality as well as resources that may be adversely affected by air pollutants.

Wilderness Act

The Wilderness Act of 1964 created the National Wilderness Preservation System in order to “secure for the American people of present and future generations the benefits of an enduring resource of wilderness.” The act defined wilderness as an area “where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain.” It directs that congressionally designated wilderness areas be protected and managed to preserve their natural conditions, with the imprint of man’s work substantially unnoticeable.

Clean Air Act

The Clean Air Act (CAA), passed in 1970 and amended in 1977 and 1990, requires the Environmental Protection Agency (EPA) to set standards for air pollutants to protect the public health and welfare. The standards, known as National Ambient Air Quality Standards (NAAQS), limit the concentrations of six common or “criteria” air pollutants that can be present in the atmosphere: ozone (O₃), particulate matter (PM), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), lead (Pb), and carbon monoxide (CO). There are standards for two categories of particulate matter—one for suspended particles less than 10 micrometers in diameter (PM₁₀) and one for fine particles less than 2.5 micrometers in diameter (PM_{2.5}). Primary standards are designed to protect public health, while secondary standards are designed to protect public welfare, which includes protection against decreased visibility and damage to animals, crops, vegetation, and buildings. These standards are shown in Table 45, below. Units of measure for the standards are parts per million (ppm) by volume, parts per billion (ppb) by volume, and micrograms per cubic meter of air (µg/m³).

Table 45 National Ambient Air Quality Standards

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide		primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead		primary and secondary	Rolling 3 month average	0.15 µg/m ³ ⁽¹⁾	Not to be exceeded
Nitrogen Dioxide		primary	1-hour	100 ppb	98th percentile, averaged over 3 years
		primary and secondary	Annual	53 ppb ⁽²⁾	Annual Mean
Ozone		primary and secondary	8-hour	0.075 ppm ⁽³⁾	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particle Pollution Dec 14, 2012	PM _{2.5}	primary	Annual	12 µg/m ³	annual mean, averaged over 3 years
		secondary	Annual	15 µg/m ³	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 µg/m ³	98th percentile, averaged over 3 years
	PM ₁₀	primary and secondary	24-hour	150 µg/m ³	Not to be exceeded more than once per year on average over 3 years

Sulfur Dioxide ⁽⁵⁾	primary	1-hour	75 ppb ⁽⁴⁾	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
	secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

(1) Final rule signed October 15, 2008. The 1978 lead standard ($1.5 \mu\text{g}/\text{m}^3$ as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

(2) The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.

(3) Final rule signed March 12, 2008. The 1997 ozone standard (0.08 ppm, annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years) and related implementation rules remain in place. In 1997, EPA revoked the 1-hour ozone standard (0.12 ppm, not to be exceeded more than once per year) in all areas, although some areas have continued obligations under that standard (“anti-backsliding”). The 1-hour ozone standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is less than or equal to 1.

(4) Final rule signed June 2, 2010. The 1971 annual and 24-hour SO_2 standards were revoked in that same rulemaking. However, these standards remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

(5) Colorado has adopted its own SO_2 secondary standard. The 3-hour average concentration cannot exceed $700 \mu\text{g}/\text{m}^3$ (or 0.267 ppm) more than once per year.

Prevention of Significant Deterioration

The Clean Air Act contains provisions for protection of air quality in areas that are meeting the ambient air quality standards. This is known as the prevention of significant deterioration (PSD) program. Under this program, areas of the country are designated as Class I or Class II. Class I areas are defined as areas of special national or regional natural, recreational, or historic value and thus receive special protection under the CAA. Class I areas include wilderness areas over 5,000 acres in size and national parks over 6,000 acres in size that were in existence in 1977. All other areas of the country have been designated as Class II.

An area’s class designation determines the maximum amount of additional air pollution, called an increment, which can be added beyond a baseline value emitted from new or modified “major” stationary sources of pollution. Increment consumption analysis falls under the PSD major sources permitting program, which is administered in Colorado by the Colorado Air Pollution Control Division (APCD). Only small amounts of pollution can be added in Class I areas, while Class II areas permit moderate amounts of pollution to be added. The Clean Air Act also charges federal land managers, including the Forest Service, with an “affirmative responsibility to protect the air quality related values (including visibility)” of Class I areas that they manage. Air quality related values are resources, as identified by the federal land manager for one or more Federal areas that may be adversely affected by a change in air quality. The resources may include visibility or specific scenic, cultural, physical, biological, ecological, or recreational resources identified by the FLM for a particular area.³⁵

Visibility

³⁵ Federal Land Managers’ Air Quality Related Values Work Group (FLAG), *Phase I Report—Revised (2010)*

The CAA amendments of 1977 set a national goal of preventing future and remedying any existing impairment to visibility in Class I areas that is caused by man-made pollution. The Environmental Protection Agency (EPA) promulgated the Regional Haze Rule in order to meet this goal. Visibility is a measure of not only how far one can see, but how well one can see important characteristics of the landscape such as form, color, geologic features, and texture. Visibility impairment is caused by the scattering of light by gases and particles in the atmosphere. Man-made pollution results in the addition of very small particles to the atmosphere, resulting in haze. A monitoring network was established by the Interagency Monitoring of Protected Visual Environments (IMPROVE) program to measure atmospheric particulate concentrations near Class I areas. The Regional Haze Rule requires states to develop air quality protection plans to reduce the pollution that causes visibility impairment in Class I areas, with a goal of achieving “natural” visibility levels within a 60 year period. EPA has provided guidance to help states estimate natural visibility for their Class I areas (http://www.epa.gov/ttn/caaa/t1/memoranda/rh_envcurhr_gd.pdf).

Hazardous Air Pollutants

Air pollutants that may cause cancer or other harmful effects such as birth defects are classified as hazardous air pollutants (HAPs). EPA is required to control emissions of 187 such hazardous air pollutants. Examples of hazardous air pollutants include benzene, which is found in gasoline; perchloroethylene, which is emitted from some dry cleaning facilities; and methylene chloride, which is used as a solvent and paint stripper by a number of industries (<http://www.epa.gov/ttn/atw/allabout.html>). The EPA has issued rules requiring that facilities belonging to 96 different classes meet emissions standards for hazardous air pollutants in order to reduce these emissions. Hazardous air pollution emissions standards can be found on the EPA’s web site (<http://www.epa.gov/ttn/atw/mactfnlalph.html>) as well as information on progress that has been made on reducing toxic emissions (<http://www.epa.gov/ttn/atw/allabout.html#progress>).

Air Quality Regulation in Colorado

The EPA has delegated to the State of Colorado the authority to enforce NAAQS and PSD increments, and to issue air quality permits. The CAA requires states to submit State Implementation Plans (SIPs) to EPA which provide for the implementation, attainment, maintenance and enforcement of the National Ambient Air Quality Standards. The Colorado Department of Public Health and Environment’s (CDPHE) APCD administers Colorado’s air quality control programs, and is responsible for enforcing the state’s air pollution laws.

The Colorado Air Pollution Control Commission oversees the development and adoption of the state’s air quality regulation program. The commission can set its own ambient air quality standards that are equally or more stringent than the Federal air quality standards. The state has adopted one additional standard (for SO₂) in addition to the federal standards; the state’s ambient air quality regulations can be found at <http://www.colorado.gov/cs/Satellite/CDPHE-Main/CBON/1251601911433>. The APCD implements the air management programs adopted by the commission and enforces compliance with the NAAQS and PSD increments.

In February 2014, the State of Colorado adopted new regulations that will affect emissions from the oil and gas industry. These include Regulation 7, which contains extensive requirements to

control emissions of ozone precursors and hydrocarbons from equipment associated with oil and gas development and production.³⁶ In addition to extensive VOC reductions, the Regulation Number 7 revisions also regulate methane emissions from the oil and gas industry.³⁷ It also adopted Regulation 6, which incorporates the federal Standards of Performance for Crude Oil and Natural Gas Production, Transmission, and Distribution Standards contained in 40 CFR Part 60, Subpart OOOO.³⁸ These provisions should result in lower emissions of methane and other hydrocarbons from oil and gas operations.

Federal Agency Compliance with Federal, State, Tribal, and Local Air Quality Standards and Regulations

The APCD implements regulatory and planning programs based on federal and state regulations. The CAA and the Federal Land Policy and Management Act of 1976 (FLPMA) require USFS and other federal agencies to comply with federal, state, tribal, and local air quality standards and regulations. FLPMA further directs the Secretary of the Interior to take any action necessary to prevent unnecessary or undue degradation of the lands [Section 302 (b)], and to manage the public lands “in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values” [Section 102 (a)(8)].

³⁶ https://www.colorado.gov/pacific/sites/default/files/T1_AQCC_5-CCR-1001-9.pdf

³⁷ <http://www.colorado.gov/cs/Satellite?blobcol=urldata&blobheadername1=Content-Disposition&blobheadername2=Content-Type&blobheadervalue1=inline%3B+filename%3D%22Regulation+Numbers+3%2C+6+%26+7+-+Fact+Sheet.pdf%22&blobheadervalue2=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1251949265521&ssbinary=true>

³⁸ <http://www.gpo.gov/fdsys/pkg/FR-2012-08-16/pdf/2012-16806.pdf>

The following map, Figure 28, shows locations of active oil and gas wells (as of Spring, 2013), locations of oil and gas well completions for years 2008 through 2012, PNG land surface available for oil and gas leasing for the Project (shaded dark green) and ozone 8-hour non-attainment area (shaded yellow).

137

elevations in the mountains to the west. Most precipitation at the upper elevations falls in the form of snow. On the grasslands, the prevailing winds are generally northwest to southeast or southwest to northeast.

The grasslands are within 100 miles of several major metropolitan areas. This proximity increases the potential for impacts from air pollution. Mobile and area sources from the Ft. Collins, Denver and Colorado Springs areas produce pollutants that impact regional air quality.

The pollutants of concern include sulfur dioxide, oxides of nitrogen, particulates (PM₁₀, PM_{2.5}) and ozone. Although many of the documented impacts are associated with external sources (those outside Forest/Grassland boundaries and jurisdiction), some activities that occur on the national forest also have the potential to impact air quality. These include prescribed and wildland fires, oil and gas development, grazing, mining, developed recreation and use of travel ways.

Wilderness areas on the Arapaho and Roosevelt National Forests closest to the project area include the Cache la Poudre, Rawah, Mt. Evans, the eastern half of the Indian Peaks and James Peak Wilderness Areas. Rocky Mountain National Park is also relatively close to the project area.

Existing Emissions from All Sources in Selected Northern Front Range Counties

The potential oil and gas development would occur in Weld County. Existing air quality conditions are generally a function of emissions loading within any particular region. Table 46 shows estimated total emissions within Weld and nearby counties in northeastern Colorado for 2011.

Table 46 2011 Emissions by County (tons)

	CO	CO ₂	N ₂ O	NH ₃	NO _x	PM ₁₀	PM _{2.5}	SO ₂	VOC
Adams	72,900	2,669,518	94	1,346	24,330	14,055	4,346	8,033	21,395
Arapahoe	85,894	2,692,975	99	632	11,876	13,296	3,350	207	17,861
Boulder	52,779	1,448,510	52	631	9,293	5,478	2,161	1,126	20,898
Broomfield	9,095	353,420	14	26	1,437	1,776	354	14	3,082
Denver	95,541	3,251,182	120	522	19,636	12,439	3,226	2,486	17,752
Douglas	51,763	1,835,874	65	468	8,508	4,983	1,457	93	18,675
Jefferson	89,211	2,941,300	109	531	13,656	6,839	2,773	2,653	27,943
Larimer	111,347	2,347,936	63	2,582	10,386	13,302	7,208	1,406	54,472
Logan	8,737	212,893	5	4,518	4,052	7,659	1,719	101	11,568
Morgan	11,648	274,751	8	5,410	7,650	6,564	1,622	13,082	10,861
Washington	7,255	137,352	3	1,763	2,746	12,463	2,570	34	13,253
Weld	68,222	1,782,317	59	16,080	25,663	27,960	6,194	575	137,717

Source: National Emissions Inventory Data (2011)

NAAQS Exceedances and Nonattainment, State Implementation Plan and General Conformity

An exceedance occurs whenever an individual measurement is recorded at an applicable federal reference method monitor that is above the level of the standard, but as the standards are

generally defined as an average of several values, an individual exceedance does not necessarily indicate a violation of an ambient air quality standard.

Areas where criteria pollutant concentrations, as determined by monitoring, exceed the NAAQS are designated by EPA to be in nonattainment. The CAA establishes timetables for each region to achieve attainment of the NAAQS, and for each area found to be in nonattainment, the state has to prepare revisions to the SIP which document how the area will reach attainment by the required date. A nonattainment plan includes inventories of emissions within the area and establishes programs that are designed to bring the area into compliance with the NAAQS.

Section 176(c) of the CAA prohibits Federal entities from taking actions in nonattainment areas that do not “conform” to the SIP. The purpose of this conformity requirement is to ensure that Federal activities: (1) do not interfere with the emissions budgets in the SIP; (2) do not cause or contribute to new violations of the NAAQS; and (3) do not impede the ability to attain or maintain the NAAQS. To implement CAA Section 176(c), EPA issued the General Conformity Rule (40 CFR Part 93, Subpart B), which applies to all Federal actions not funded under U.S.C. Title 23 or the Federal Transit Act (USFS actions are not funded by U.S.C. Title 23 or the Federal Transit Act). The General Conformity Rule established emissions thresholds (40 CFR 93.153), known as “de minimis” levels, for use in evaluating the conformity of a project. If the net emissions increases due to the project are less than these thresholds, the project is presumed to conform and no further conformity evaluation is required. If the emissions increases exceed any of these thresholds, a formal conformity determination is required. The conformity determination can include air quality modeling studies, consultation with EPA and state air quality agencies, and commitments to revise the SIP or to implement measures to mitigate air quality impacts. The federal entity with jurisdiction for the proposed action must demonstrate that the proposed action meets the requirements of the General Conformity rule.

Existing Air Quality Conditions: NAAQS Compliance

Ambient air quality in the affected environment (i.e. compliance with the NAAQS) is demonstrated by monitoring for ground level atmospheric air pollutant concentrations. Table 47, below, presents the maximum measured concentrations for criteria pollutants within select counties in northeastern Colorado near the project area for 2011-2013 (no data were available for lead). Exceedances of the standard are highlighted in yellow. The data in the table excludes exceptional events, which are defined as “unusual or naturally occurring events that can affect air quality but are not reasonably controllable using techniques that tribal, state or local air agencies may implement in order to attain and maintain the National Ambient Air Quality Standards” (<http://www.epa.gov/ttn/analysis/exevents.htm>).

Table 47 Maximum Measured Criteria Pollutant Concentrations for Select Counties in Northeastern Colorado: 2011 to 2013.

County	CO 2nd Max 1-hr (ppm)	CO 2nd Max 8-hr (ppm)	NO ₂ 98th percent 1-hr (ppb)	Ozone 2nd Max 1- hr (ppm)	Ozone 4th Max 8- hr (ppm)	SO ₂ 99th Percent 1-hr (ppb)	SO ₂ 2nd Max 24-hr (ppb)	PM _{2.5} 98th Percent 24-hr (µg/m ³)	PM _{2.5} Weighted Mean 24- hr (µg/m ³)	PM ₁₀ 2nd Max 24-hr (µg/m ³)
2013										
Adams	2.4	2.1	58	0.1	0.076	30	5	27	8.7	97
Boulder	.	.	.	0.09	0.079	.	.	23	7.1	51
Denver	5.7	2.5	68	0.09	0.071	38	11	29	8.8	76
Larimer	2.5	1.4	.	0.1	0.08	.	.	18	6.8	55
Weld	3	1.7	.	0.09	0.072	.	.	21	7.2	47
2012										
Adams	2.2	1.3	64	0.09	0.072	28	5	26	8.6	91
Boulder	.	.	.	0.09	0.074	.	.	28	7.2	43
Denver	4	2	72	0.09	0.074	39	10	37	8.2	103
Larimer	2.5	1.7	.	0.1	0.079	.	.	26	7.3	91
Weld	3.2	1.6	.	0.1	0.074	.	.	32	7.9	91
2011										
Adams	2.4	1.6	64	0.1	0.075	30	5	20	7.6	65
Boulder	4.3	2.1	.	0.1	0.076	.	.	19	6.4	33
Denver	3.1	1.8	72	0.09	0.074	34	7	20	7.5	92
Larimer	2.5	1.3	.	0.1	0.08	.	.	15	5.7	40
Weld	2.5	1.5	.	0.09	0.077	.	.	23	7.4	46
NAAQS	35	9	100		0.075	75	500	35	12	150

Source: http://www.epa.gov/airdata/ad_rep_con.html

As shown in Table 47, ozone exceedances occurred in Adams, Boulder, Larimer and Weld Counties between 2011 and 2013. Areas that meet federal ambient air quality standards are classified as being in attainment, while areas not meeting standards are classified as being in nonattainment. On April 30, 2012, the EPA finalized its ozone nonattainment designations with respect to the 2008 ozone standard (<http://www.epa.gov/airquality/ozonepollution/designations/2008standards/final/region8f.htm>). EPA identified only one nonattainment area in Colorado for ozone that includes part or all of Denver, Adams, Arapahoe, Boulder, Broomfield, Douglas, Jefferson, Larimer, and Weld counties (roughly the Denver-Boulder-Greeley-Fort Collins metropolitan areas). EPA has not identified any current nonattainment areas in Colorado for any of the other criteria pollutants.

Five exceedances of the 8 hour ozone standard occurred in Weld County in 2011 and three in 2012. These exceedances were recorded by the Greeley monitor. No exceedances were recorded in 2013.

The NAAQS include standards for particulate matter in two size ranges: all particulate matter less than 10 microns in size (PM_{10}); and particulate matter less than 2.5 microns in size (referred to as fine particulate or $PM_{2.5}$). $PM_{2.5}$ is the major cause of reduced visibility (haze). Fine particulate matter ($PM_{2.5}$) is chiefly comprised of five mass types: organic mass, elemental carbon (also known as soot or black carbon), ammonium sulfates, ammonium nitrates, and crustal materials (i.e., soil). Primary, fine particulate emissions result from combustion processes (including fossil fuel combustion and biomass combustion that occurs in wildfires) and include black carbon. In general, however, black carbon and crustal materials comprise a relatively small proportion of the fine particulate mass suspended in the atmosphere. Some fine particulates ($PM_{2.5}$), principally ammonium sulfate and ammonium nitrate particles, can also be formed in the atmosphere from the interaction of SO_2 or nitrogen oxides and ammonium. These types of $PM_{2.5}$ particles are referred to as secondary particulates, while particles emitted directly from a source are referred to as primary particulates. The largest constituents of fine particulate are usually organic mass, ammonium nitrates, and ammonium sulfates.

Particulate matter, specifically $PM_{2.5}$, poses a health hazard to humans because it can be inhaled and reach deep into the lungs. Health impacts from $PM_{2.5}$ include respiratory problems, aggravated asthma, and bronchitis. High particulate levels are associated with increased hospital and emergency room visits. Table 47 shows just one exceedance of the $PM_{2.5}$ NAAQS within the listed counties, in Denver County in 2012. There are no nonattainment areas associated with particulate matter within Colorado.

Existing Conditions: Ozone

Ozone (O_3) is a gas that occurs both within the Earth's upper atmosphere (stratosphere) and at ground level (troposphere). Stratospheric ozone extends about 6 to 30 miles above the Earth's surface and serves to protect life on Earth from the sun's harmful ultraviolet rays. Occasionally small amounts of stratospheric ozone will briefly migrate downwards and add to ozone concentrations at the earth's surface. Typically these instances are associated with the passage of an upper level low pressure trough (Musselman et.al. 1998).

Unlike most other criteria pollutants, ozone is not emitted to the atmosphere directly; it is formed when nitrogen oxides and volatile organic compounds react in the presence of sunlight. Ozone formation is highly dependent on meteorological conditions, including temperature, wind speed, and solar radiation. Ozone in the lower atmosphere is harmful to human health and vegetation. In general, ozone concentrations in the lower atmosphere are highest during warmer months and lower in the cooler months. In some parts of the western U.S., high wintertime ozone concentrations have been monitored. The project area is not in an area with monitored high winter ozone concentrations. The chemical reactions that form ozone are complicated and nonlinear, making it difficult to predict ozone concentrations that will result from increasing the amount of the ozone precursors (i.e., nitrogen oxides and volatile organic compounds) in the atmosphere. The effect of adding nitrogen oxides or volatile organic compounds to the atmosphere on the concentration of ozone depends upon the ratio of the two precursors already present. Ozone formation is also highly dependent on meteorological conditions, including

temperature, wind speed, and solar radiation. Ozone in the lower atmosphere is harmful to human health and vegetation.

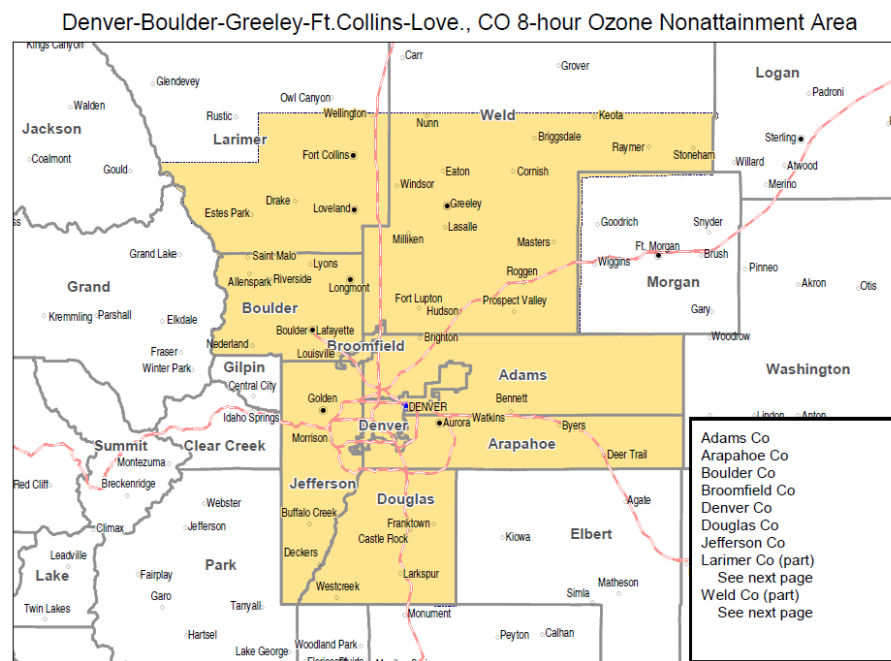
Natural sources of ozone precursors include trees, soil, forest fires, and lightning. Naturally occurring ozone is at low concentrations that are not considered a threat to human health or the environment.

Anthropogenic sources of ozone precursors present in Colorado include local, regional, national and global sources of NO_x and VOCs. A 2004 report prepared for the Denver Early Action Compact indicated that transported ozone “significantly” impacted the final ozone concentration recorded in the Denver region (Parsons and Arnold 2004). Correlation between ozone reductions or increases and sources (local vs transported) is difficult although the CDPHE did find a correlation between reduced power plant emissions in northeast Colorado and ozone along the Front Range (Reddy 2010).

Elevated levels of ozone can adversely impact human respiratory health and impede plant growth. Major sources of VOCs and NO_x include industrial facilities, electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents. Sunlight and warm weather accelerate the reaction, which is why high ozone levels are typically seen in the summer.

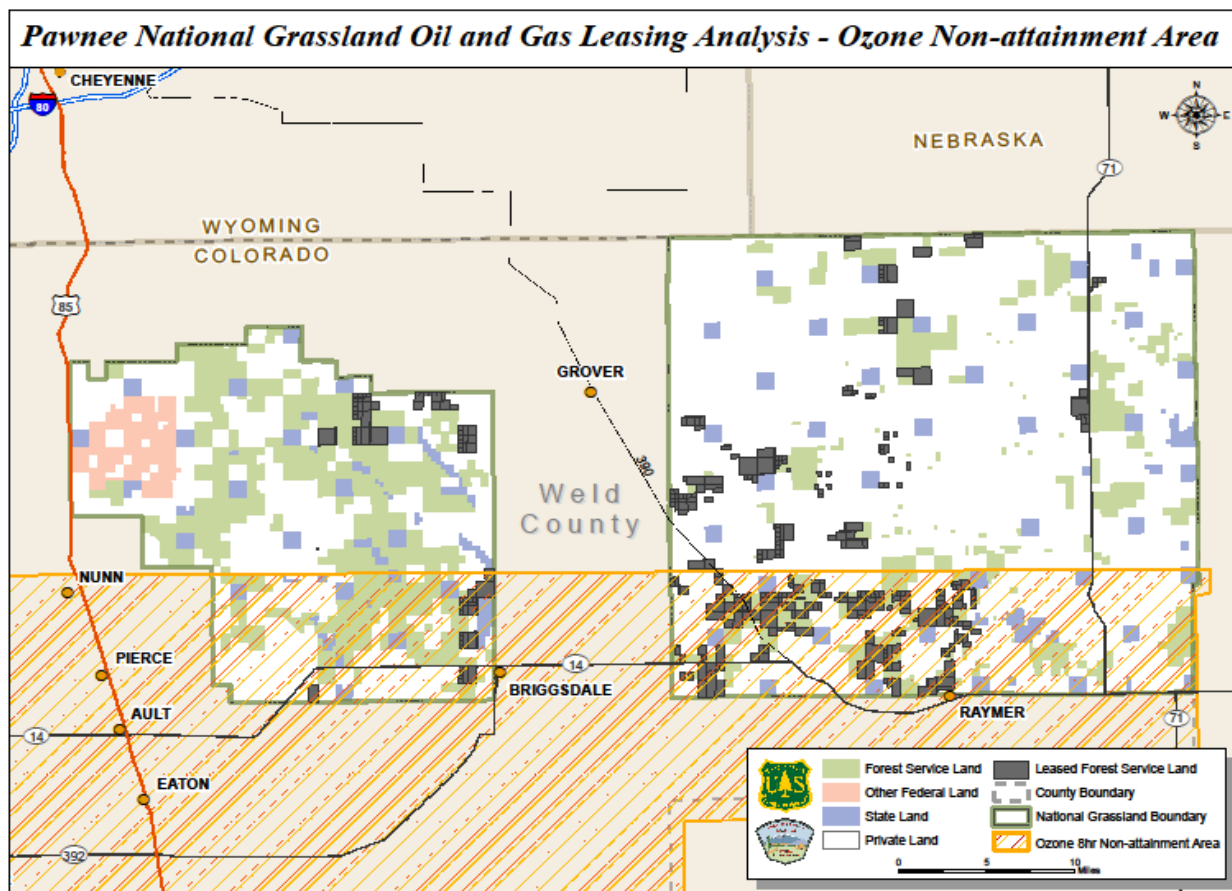
A portion of the Pawnee National Grasslands (along the southern boundary) is located within the Denver Metro-North Front Range 8-hour Ozone Nonattainment Area, and any potential development within the nonattainment area will be required to comply with the General Conformity rule. The following map (Figure 29) shows the full extent of the Denver-Boulder-Greeley-Fort Collins-Loveland Ozone Nonattainment Area. Figure 30 shows the portion of the Pawnee NG that is included in the nonattainment area.

Figure 31 Ozone Nonattainment Area



Boundaries and locations are for illustrative purposes only. This is not a regulatory document.

Figure 32 Land Ownership and the Ozone Nonattainment Area on the Pawnee National Grassland



Ozone Design Value

A design value is a statistic that describes the air quality status of a given location relative to the level of the National Ambient Air Quality Standards (NAAQS). The design value at a monitoring site is the statistic used to compare to the standard. For ozone, this is the three year average of the annual 4th-highest 8-hour ozone concentration. EPA uses the highest value of the statistic observed at any monitor within a nonattainment area as the design value for that area. These values are published on an annual basis. The current design value for the Denver metropolitan nonattainment area is shown below in Figure 31.

Figure 33 Design Values in Areas Previously Designated Nonattainment for the 8-Hour Ozone NAAQS

Designated Area	Designation Status ¹	Classification ¹	2010-2012 Design Value (ppm) ^{2,3}	Meets NAAQS?
Denver-Boulder-Greeley-Ft Collins-Loveland, CO	Nonattainment	Marginal	0.082	No

Source: <http://www.epa.gov/airtrends/values.html>

Notes:

1. Area classification and designation status as of July 23, 2013.

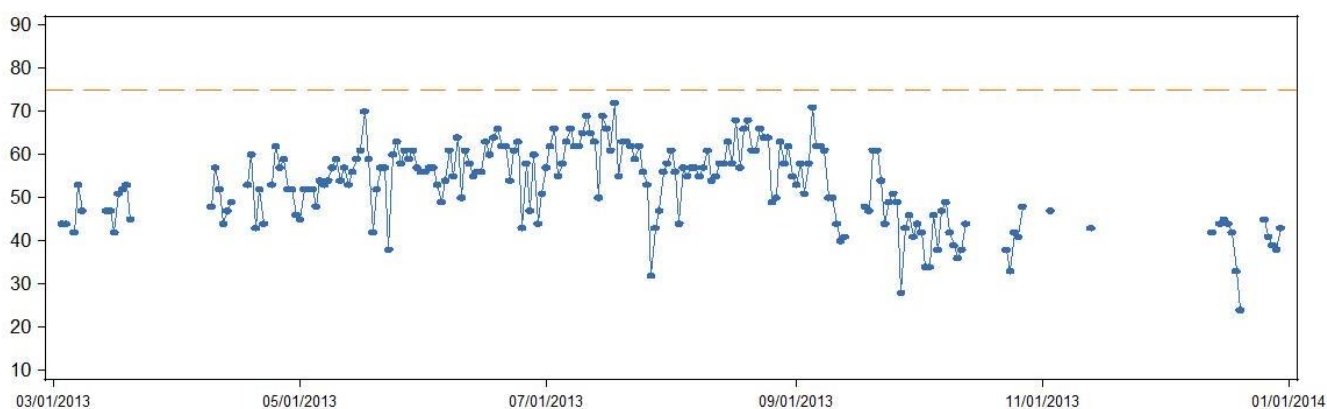
2. The level of the 2008 8-hour ozone NAAQS is 0.075 parts per million (ppm). The design value is the 3-year average of the annual 4th highest daily maximum 8-hour ozone concentration.
3. The design values shown here are computed using Federal Reference Method or equivalent data reported by State, Tribal, and Local monitoring agencies to EPA's Air Quality System (AQS) as of June 28, 2013. Concentrations flagged by State, Tribal, or Local monitoring agencies as having been affected by an exceptional event (e.g., wildfire, volcanic eruption) and concurred by the associated EPA Regional Office are not included in these calculations.

Additional Ozone Monitoring Data

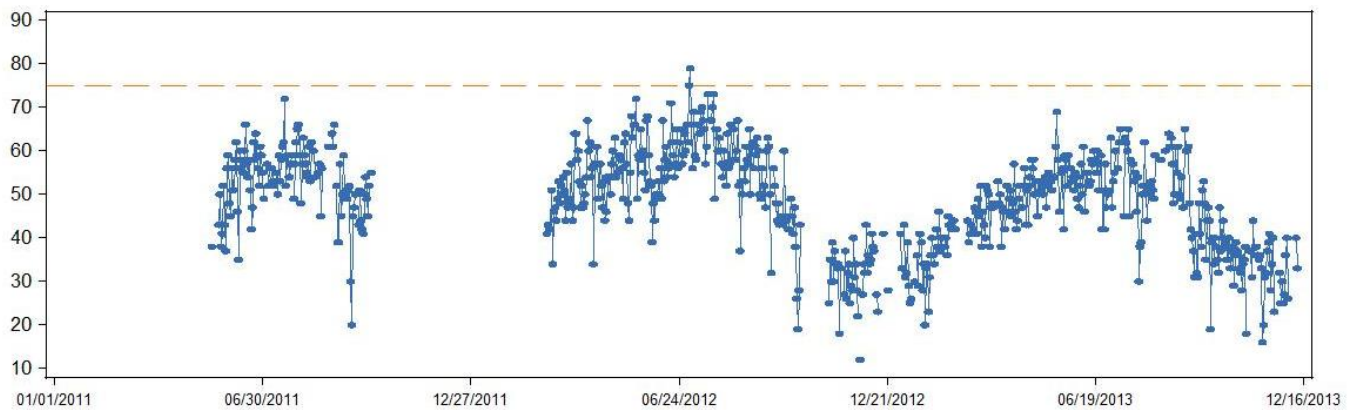
The US Forest Service has recently established two ozone monitors on the Pawnee NG. These monitors are located at Briggsdale and Dave's Draw, which is near the Pawnee Buttes. The monitors are operated by the USFS Rocky Mountain Research Station in Fort Collins, Colorado. Because these monitors are not operated as regulatory monitors, the data from them cannot be used to officially determine compliance with the NAAQS. Most state regulatory monitors are located near urban areas, and none are located within the borders of the Pawnee NG. The FS therefore installed monitors to provide additional local information on ozone concentrations within this area. The USFS is committed to continuing ozone data collection at Briggsdale and Dave's Draw for as long as adequate funding and personnel are available. Data from these monitors are shown in the plots below (Figure 32). These monitors do not operate all year. The plots show all available daily maximum 8-hour average ozone concentrations. The red line on each plot indicates the ozone standard (75 ppb). The lowest 8-hour concentration exceeding the standard is 76 ppb. As indicated by the plots, only one value that exceeded the standard was observed, at Briggsdale in 2012.

Figure 34 Daily Maximum 8-hour Ozone Concentrations at Pawnee NG Monitors

Daily Maximum 8-Hour Average Ozone Concentration (ppb) Pawnee Buttes



Daily Maximum 8-Hour Average Ozone Concentration (ppb) Briggsdale

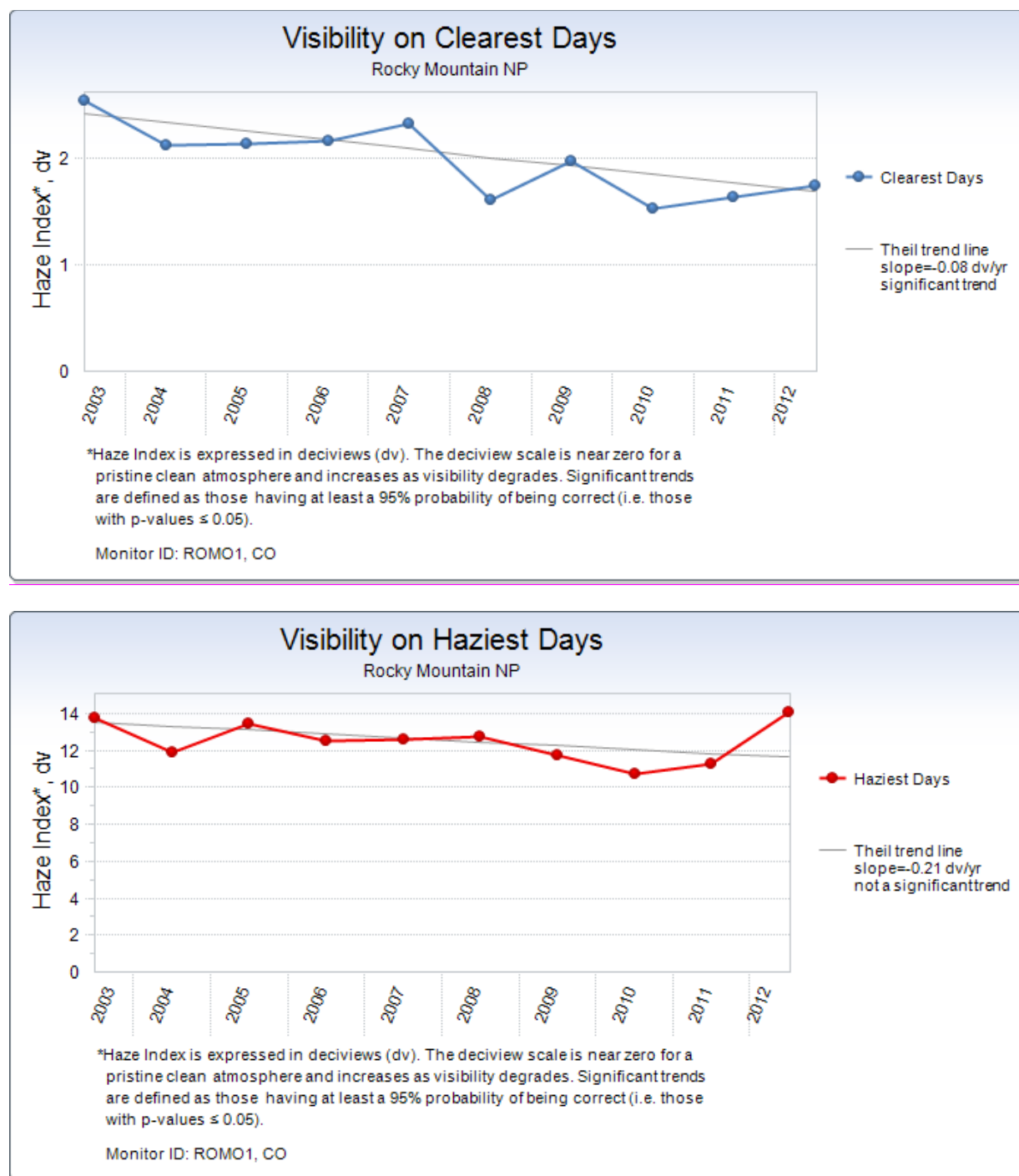


AQRV: Visibility

Visibility impairment is caused by the scattering of light by gases and particles in the atmosphere. Manmade emissions of air pollutants contribute to the loading of particulates in the atmosphere that cause haze. Fine particulates ($PM_{2.5}$) have the largest contribution to haze. Visual range, i.e., the greatest distance at which an observer can distinguish an object from the background, is an easily understood way to describe visibility. Visual range, however, is not linear with perceived changes in visibility. For instance, a 5 kilometer change in visual range is more easily seen where the air is quite clear than when it is hazy. For this reason, visibility is usually described in terms of an index called the deciview that is linear with perceived changes in visibility. A change of 1.0 deciview is equivalent to a ten percent change in light extinction and represents a just noticeable change in visibility. The higher the deciview, the less a person can see into the distance.

Visibility at Class I areas is monitored through the Interagency Monitoring of Protected Visual Environments (IMPROVE) program, which maintains a network of particulate monitors. Visibility on the 20% clearest and haziest days is tracked to measure progress toward the national visibility goal as required by the Regional Haze Rule. The closest IMPROVE monitor to the project area is located at Rocky Mountain National Park, approximately 75 kilometers to the west. Figure 33 shows trends in annual mean visibility on the clearest and haziest days at Rocky Mountain National Park. The plots show the data overlaid with the trend in time. The data indicate a statistically significant downward (improving) trend on the clearest days. No significant trend is noted on the haziest days.

Figure 35 Trend in haze index (deciview) on the 20% clearest and haziest days at Rocky Mountain National Park.



AQVR: Atmospheric Deposition

Air pollutants can be deposited through precipitation (such as rain or snow) or by dry settling processes to surfaces on the ground such as soils and water bodies. Deposition of some types of pollutants, particularly nitrogen and sulfur compounds (e.g., nitrate and sulfate), can lead to

acidification of lakes and streams. Acidification of surface waters can negatively affect aquatic organisms such as zooplankton, algae, diatoms, invertebrates, amphibians, and fish. Nitrogen can cause other ecosystem impacts by fertilizing both soils and water. These excess inputs of nitrogen can disrupt the natural flora and fauna by allowing certain species that would not naturally occur in abundance to out-compete those that thrive in pristine nitrogen-limited systems. The end result is an unnatural shift in species composition for sensitive species, which may have a subsequent impact on other components of the ecosystem.

The chemistry of wet precipitation (rain and snow) is monitored by the National Atmospheric Deposition Program (NADP), an interagency organization that maintains a network of samplers located across the country. The closest NADP monitor to the project area (CO22) is located at the State Agricultural Experiment Station on the west side of the Pawnee National Grassland. Data from this monitor are shown in Figures 34, 35, and 36. Figures 34 and 35 show the concentrations of nitrate and sulfate in wet precipitation in microequivalents per liter ($\mu\text{eq/l}$). Figure 36 shows the total annual wet deposition of nitrogen. The NADP has established completeness criteria for deposition data. The colors of the symbols on the three plots indicate when the completeness criteria were not met, as shown in the plot legends.

Figure 36 Annual trends in nitrate (NO_3) concentrations in wet deposition collected by the Pawnee (CO 22) National Atmospheric Deposition Program monitor.

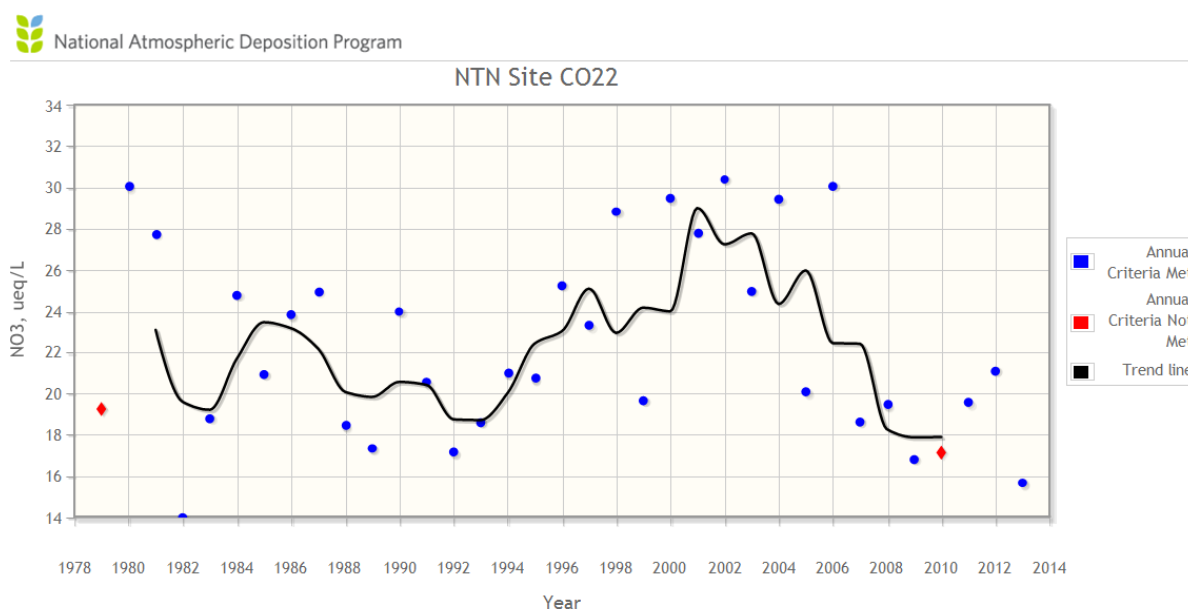


Figure 37 Annual trends in sulfate (SO₄) concentrations in wet deposition collected by the Pawnee (CO 22) National Atmospheric Deposition Program monitor.

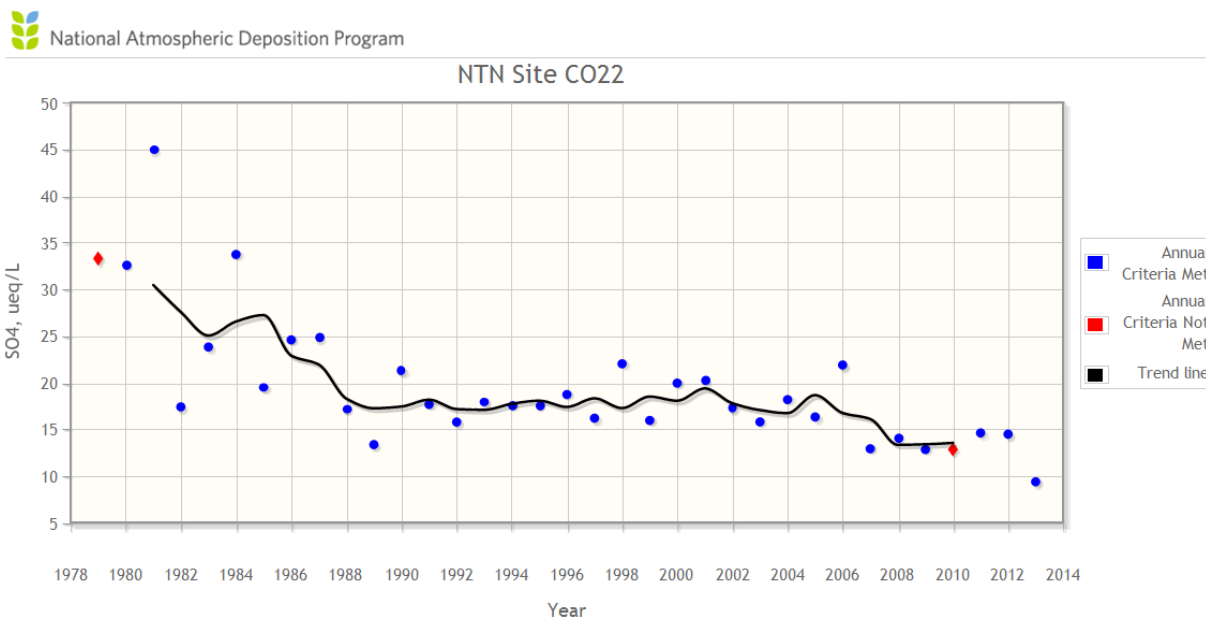
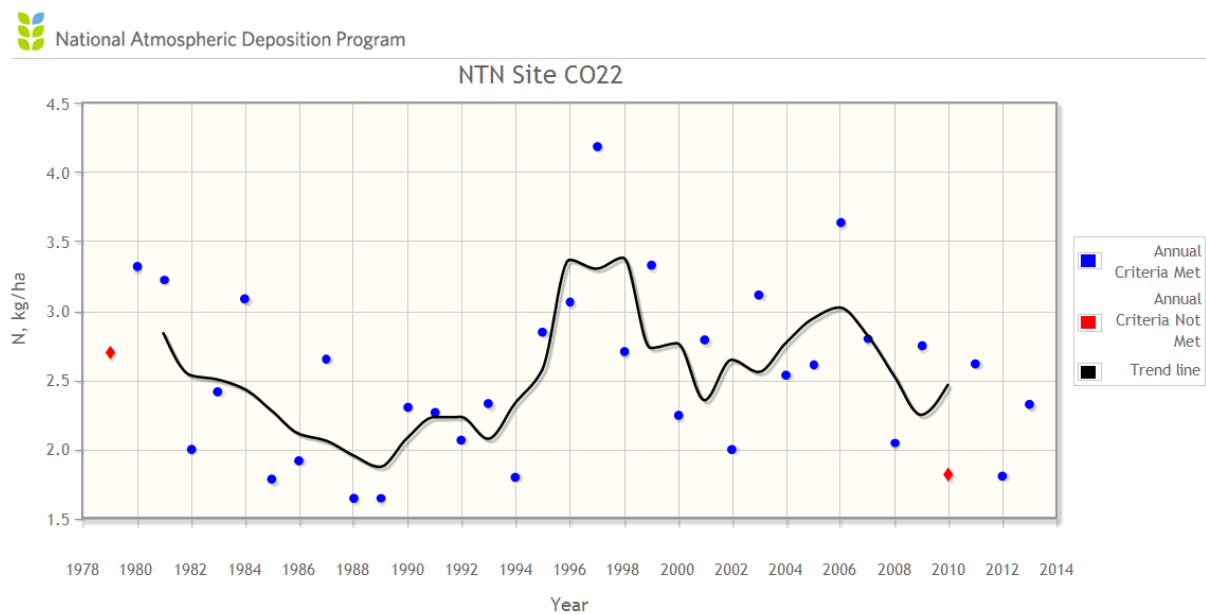


Figure 38 Annual trends in wet nitrogen deposition collected by the Pawnee (CO 22) National Atmospheric Deposition Program monitor.



Plot notes (applicable to Figures 22-24):

The annual weighted mean concentrations and depositions are characterized as meeting or not meeting the NADP's data completeness criteria for the 1-year period.

1. Valid samples for 75% of the time period
2. Valid samples for 90% of the precipitation amount
3. Precipitation amounts for 75 % of the time period

Trend line

The trend line is a smoothed 3-year moving average with a one-year time step. The line is only displayed where the minimum data completeness criteria is met for the 3-year period.

Source: <http://nadp.sws.uiuc.edu/sites/siteinfo.asp?net=NTN&id=CO22>

The closest NADP monitors located at a Class I area are at Rocky Mountain National Park. The park operates two NADP monitors, one at a lower elevation at Beaver Meadows (monitor CO19) and two monitors at a higher elevation site at Loch Vale (monitors CO89 and CO98). Data from those monitors indicate that nitrogen deposition in precipitation at the park varies from around 1.5 to 3.5 kilograms per hectare per year. The National Park Service has set a critical load for nitrogen deposition in precipitation at the park of 1.5 kilograms per hectare per year (<http://www.nature.nps.gov/air/Studies/criticalloads/criticalLoadExplain.cfm>). A critical load is a level of deposition below which significant harmful ecosystem effects are not known to occur. The park has recently partnered with a number of organizations to look at ways to reduce nitrogen deposition levels in the park. Participants in this effort, referred to as the Rocky Mountain National Park Initiative, include the Colorado Department of Public Health and Environment Air Pollution Control Division, U.S. Environmental Protection Agency (EPA) Region 8 Air Program, the Air Resources Division of the National Park Service and the U.S. Forest Service (<http://www.colorado.gov/cs/Satellite/CDPHE-AP/CBON/1251594862555>).

Greenhouse Gases and Climate Change

There is broad scientific consensus that humans are changing the chemical composition of earth's atmosphere. Activities such as fossil fuel combustion, deforestation, and other changes in land use are resulting in the accumulation of trace greenhouse gases (GHGs) such as carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and several industrial gases in the Earth's atmosphere. An increase in GHG emissions is said to result in an increase in the earth's average surface temperature, primarily by trapping and thus decreasing the amount of heat energy radiated by the earth back into space. The phenomenon is commonly referred to as global warming. Global warming is expected in turn, to affect weather patterns, average sea level, ocean acidification, chemical reaction rates, and precipitation rates, which is collectively referred to as climate change.

The Intergovernmental Panel on Climate Change (IPCC) has predicted that the average global temperature rise between 1990 and 2100 could be as great as 5.8°C (10.4°F), which could have massive deleterious impacts on the natural and human environments. Although GHG levels have varied for millennia (along with corresponding variations in climatic conditions), industrialization and the burning of fossil carbon fuel sources have caused GHG concentrations to increase measurably, from approximately 280 ppm in 1750 to 400 ppm in 2014 (as of April). The rate of change has also been increasing as more industrialization and population growth is occurring around the globe. This fact is demonstrated by data from the Mauna Loa CO₂ monitor in Hawaii that documents atmospheric concentrations of CO₂ going back to 1960, at which point the average annual CO₂ concentration was recorded at approximately 317 ppm. The record shows that approximately 70% of the increases in atmospheric CO₂ concentrations since pre-industrial times occurred within the last 54 years.

Three of the most important greenhouse gases (GHG) resulting from human activity are carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). They are produced by both natural processes and human activity. While they make up less than one percent of the Earth's atmosphere, they exert a powerful influence over global temperatures.

Greenhouse gases play a role in the natural environment by absorbing the sun's heat. As the sun's energy radiates back from the Earth's surface toward space, these gases trap the heat in the atmosphere keeping the planet's surface warmer than it would otherwise be. Increases of atmospheric greenhouse gases result in additional warming of the Earth's atmosphere. Carbon dioxide equivalents (CO₂e) is a metric used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). For instance, over a 100 year period the GWP of methane (CH₄) is estimated to be about 21 times greater than carbon dioxide (CO₂), so its carbon dioxide equivalent (CO₂e) is 21³⁹. The carbon dioxide equivalent (CO₂e) of nitrous oxide (N₂O) is 310 (EPA 2005).

Globally the average annual temperature has risen since 1900 by about 1.5°F and is expected to rise another 2 to 10°F by 2100. The average annual temperature in the United States has risen by a comparable amount over the same time period but is expected to rise more than the global average over this century (Karl et al. 2009).

In 2005 Colorado's greenhouse emissions were 35 percent higher than they were in 1990. They are projected to grow 81 percent above the 1990 levels by 2020 (CDPHE 2010). Climate change related impacts observed in Colorado in recent decades include shorter and warmer winters with reduced snowpack and earlier spring runoff, more precipitation falling as rain rather than snow, and longer periods of drought (CDPHE 2010).

GHG Emissions from Oil and Gas Development and Operations

Energy-related activities in the United States account for three-quarters of human-generated GHG emissions. These activities account for 97 percent of carbon dioxide (CO₂), 37 percent of methane (CH₄) and 13 percent of nitrous oxide (N₂O) emissions in the country (EPA 2010a). Stationary sources such as power plants make up more than half of the energy-related emissions. Transportation's contribution is one third of these emissions (CDPHE 2010).

Natural gas is one of the top three major fuel sources that contribute to the United States' energy-related emissions of carbon dioxide (CO₂). Petroleum contributes about 42 percent of the total emissions, coal comes in second with approximately 37 percent, and natural gas contributes 21 percent (DOE 2009).

Aside from GHG emissions from fossil fuel consumption in the United States, the production, transmission, storage, and distribution of natural gas contributes to less than one percent of carbon dioxide (CO₂) emissions and about 17 percent of methane (CH₄) emissions. The source of most of these emissions is leakage from wells, pipelines, well-site treatment facilities, pneumatic devices, compressors, storage facilities, and other related systems. Carbon monoxide (CO), volatile organic compounds (VOCs), and nitrogen oxides (NO_x) are also emitted but in much smaller quantities (EPA 2010a).

³⁹ EPA lists the GWP of methane as 21 on its website (<http://epa.gov/climatechange/ghgemissions/gases/ch4.html>). In its 2013 rulemaking, however, EPA lists the value for the 100-year GWP of methane as 25. See Federal Register, Vol. 78, No. 230, p. 71909, available at <http://www.gpo.gov/fdsys/pkg/FR-2013-11-29/pdf/2013-27996.pdf>

The EPA has recognized the significance of equipment leaks and vented GHG emissions from both the natural gas and petroleum industries. A recent ruling by the EPA requires mandatory reporting of GHG from facilities that annually emit 25,000 metric tons or more of carbon dioxide (CO₂) equivalent (EPA 2010b).

3.10.2 Environmental Impacts to Air Quality from Potential PNG Oil and Gas Development

No alternatives specifically propose the exploration or development of oil and gas resources. For this reason, the leasing analysis relies on the RFD which projects future potential surface disturbing activities to provide a development scenario for the proposed available lands. However, this scenario is not entirely foreseeable and is dependent on future industry interest, access, market values and many other factors.

Project Area and Alternatives

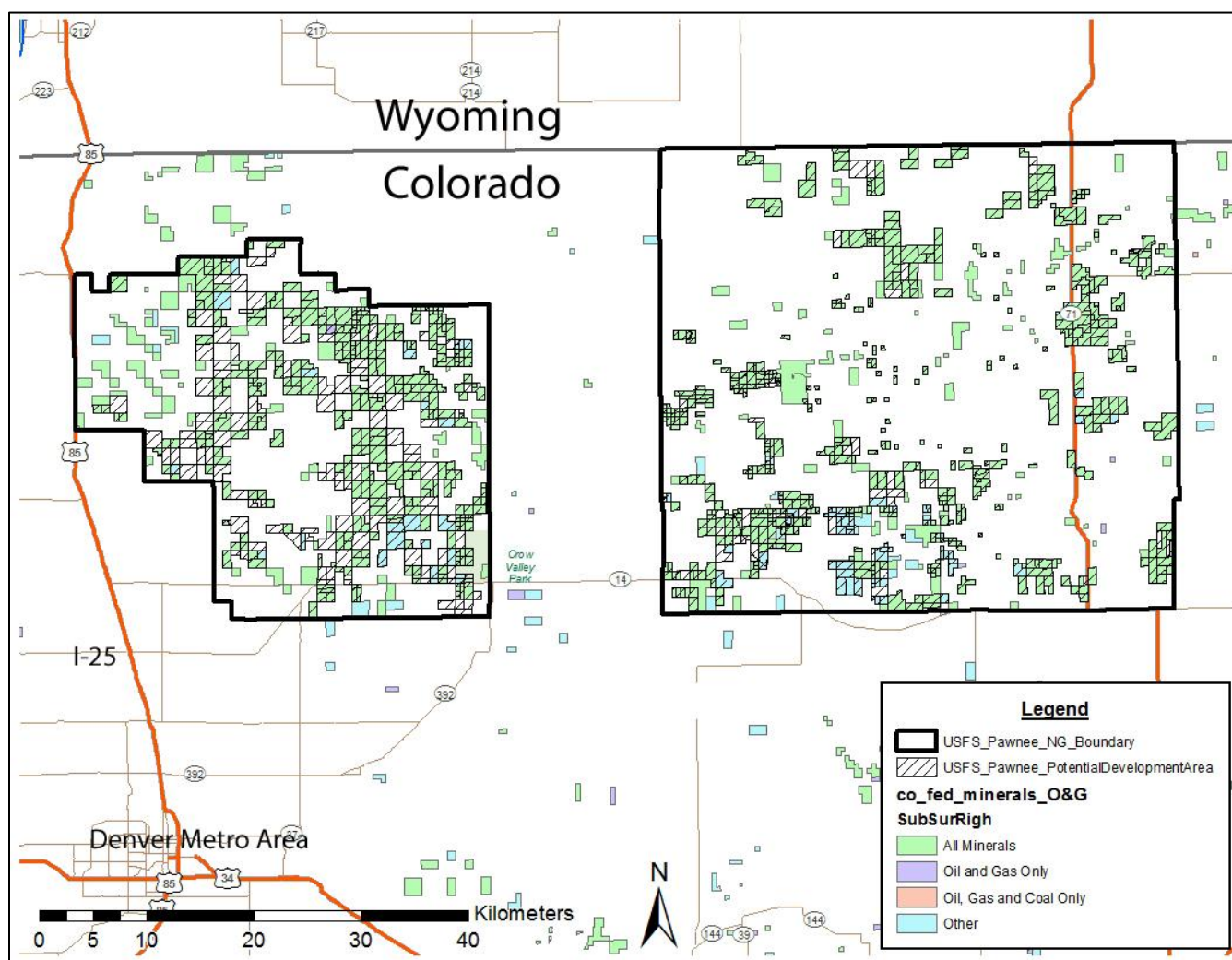
As described earlier in, the Pawnee National Grassland (PNG) contains a mixture of federal and private mineral estate. A portion of the federal mineral estate has been leased, while the remainder is unleased. Chapter 2 describes the three alternatives being considered for this leasing analysis. These are: (1) no leasing; (2) no action; and (3) leasing under no surface occupancy (NSO). Under Alternatives 2 and 3, the unleased portion of the federal mineral estate would be available for leasing and the reasonably foreseeable development (RFD) would be the same. For these alternatives, the reasonably foreseeable development projects that up to 265 new and exploratory wells could be drilled, and up to 234 producing wells would remain in the long term. Under Alternative 1, no leasing would occur and thus no oil and gas development would be allowed. However, as explained in Chapter 2, it is likely that additional private development would occur that would result in a somewhat larger number of wells being drilled due to the need to avoid federal surface and mineral estate. This could result in up to 292 new and exploratory wells being drilled, of which 257 producing wells would remain in the long term. Therefore, for the air quality analysis, all three alternatives would result in approximately the same level of emissions and thus the same impacts to air quality.

Analysis Area

Because the PNG exists in an area of mixed federal and non-federal surface ownership, the analysis area for air quality effects for this analysis includes all potential wells from the RFD that would access Federal minerals within the boundary of the PNG. This is the area within the black borders in Figure 37. Within this area, up to 354 wells accessing Federal minerals are projected. The map in Figure 37 also shows the areas of Pawnee NG surface within the potential development area (designated with black hash marks) and areas of Federal minerals (colored in blue, pink or light green). Under Alternatives 2 and 3, up to 265 wells could be drilled. These include the wells that would intersect the Federal minerals underneath the Pawnee potential development areas shown in the map. The remaining wells (89) would intersect Federal minerals but not under the PNG potential development areas (e.g., these could include wells drilled into Federal minerals under private surface). For air quality, the potential effects of all wells that would access Federal minerals and associated development within the PNG boundary were considered. Under Alternative 1, no lands would be leased but it is anticipated that additional private development would occur in the absence of leasing, as discussed earlier, resulting in the

same impacts to air quality. Therefore, the potential impacts of up to 354 wells and associated development were analyzed for all three alternatives.

Figure 39 Air Quality Analysis Area



Effects of Making Lands Available for Oil and Gas Leasing

This analysis does not disclose direct impacts because this decision addresses making lands available for oil and gas leasing and under certain conditions (lease stipulations). As a result of making lands available for oil and gas leasing, any subsequent development would be considered an **indirect** effect of this decision. Leasing is a commitment of the resource for potential future exploration and development activities, but it does not compel or authorize any ground disturbing actions in support of the exploration or development of a lease. As a result of leasing, future exploration and development proposals could be brought forward that would be subject to additional site specific environmental study and permitting requirements.

Environmental Impacts

The analysis presented here provides sufficient information for this level of decision, where the decision under consideration is whether or not to make lands available for leasing. As there is no way at this time to accurately project the exact location, nature, and extent of oil and gas

development that might occur as a result of this decision, the air quality analysis considered a conservative but reasonable scenario based upon the RFD that included all wells within the boundary of the Pawnee NG. The number of wells analyzed was somewhat higher than the number of wells projected under any of the alternatives, and should therefore provide an upper bound to potential air quality impacts.

Any future exploration or development of oil and gas resources, if and when it does occur, would result in direct, indirect and cumulative impacts. Those future impacts, specific to a proposed project, will be disclosed through additional environmental study and the federal leasing and development process.

Potential future impacts to air resources could result if reasonably foreseeable future actions were to occur. Thus, potential future oil and gas development was disclosed through the RFD scenarios. Associated emissions were calculated and are disclosed in the emissions inventory. Potential future impacts from these emissions are described below.

Effects of Future Development

The decision to offer the identified lands for lease would not result in any direct emissions of air pollutants. However, future development of these leases will result in emissions of criteria pollutants, including carbon monoxide, nitrogen oxides, sulfur dioxide, particulate matter, and volatile organic compounds. It will also result in emissions of hazardous air pollutants and greenhouse gases. Emissions of nitrogen oxides and volatile organic compounds will contribute to ozone formation. Impacts resulting from development of oil and gas leases will be addressed in a subsequent analysis when lessees file an APD. The analysis conducted at that time will determine if any contemporaneous incremental increases from project emissions cause significant impacts at the local and regional scales. All proposed activities including, but not limited to, exploratory drilling activities would be subject to applicable local, state, and Federal air quality laws and regulations.

Any subsequent activity authorized after APD approval could include soil disturbances resulting from the construction of well pads, access roads, pipelines, power lines, and drilling. Any disturbance is expected to cause increases in fugitive dust and potentially inhalable particulate matter (specifically PM₁₀ and PM_{2.5}) in the project area and immediate vicinity. Particulate matter, mainly dust, may become airborne when drill rigs and other vehicles travel on dirt roads to drilling locations. Air quality may also be affected by exhaust emissions from engines used for drilling, transportation, gas processing, compression for transport in pipelines, and other uses.

Potential Near field Impacts

Potential near-field impacts for areas close to potential development sites were not evaluated for this analysis. Near-field effects are strongly dependent upon the characteristics of individual development sites such as the number of wells per pad, the types of equipment in use, topography, and other factors that cannot be determined (or reasonably estimated) at this time. This type of analysis can only be meaningfully completed once a project is proposed and more detailed information is available so that useful results can be obtained. Under Alternatives 2 and 3, any future drilling of Federal minerals within the Pawnee NG boundary will require approval from the BLM and further NEPA analysis, including the drilling of federal minerals from private

surface. The near-field analysis will include estimates of nearby impacts to the following standards:

- 1-hour and annual NO₂,
- PM_{2.5} 24-hour and annual,
- PM₁₀ 24-hour, and
- hazardous air pollutants, to include benzene, toluene, ethyl benzene, xylene, and formaldehyde.

Impacts to 1-hour and 3-hour SO₂, as well as 1-hour and 8-hour CO, may be included if needed; this will be determined on a case-by-case basis, depending on the amount of emissions and potential for impacts. Impacts to lead will not be assessed as oil and gas projects are typically not meaningful sources of lead emissions, and ozone cannot be assessed in the near-field. This analysis is typically performed by the BLM when approving an APD. If necessary, mitigation will be applied at that time as a condition of approval in order to ensure that federal and state air quality standards are not exceeded and that AQRV impacts are acceptable. Under Alternative 1, no additional leasing of federal minerals would occur and therefore there would be no additional NEPA analysis associated with unleased portions of the Pawnee NG, although additional development is likely to occur on private surface and private minerals surrounding the federal lands (see description of Alternative 1).

Potential Far Field Impacts

Far-field impacts that could result under these alternatives were assessed using a quantitative air quality model. An air quality model consists of a series of computer programs, and it is used to mathematically simulate atmospheric conditions and behavior. Using inputs such as meteorology and source emissions, an air quality model can calculate estimated pollutant concentrations in the air or the amount of pollution deposited (deposition) on the ground from the air.

The air quality modeling results disclosed here came from a larger study conducted by the BLM that includes emissions from the entire continental US, but focuses on new oil and gas development and air quality impacts in Colorado, called the Colorado Air Resource Management Modeling Study (CARMMS). This study is examining the potential air quality impacts from future oil and gas development that might occur through the year 2021. CARMMS is an on-going effort being conducted by the Colorado BLM for use in land management planning and project-specific analyses that is examining impacts to air quality from a number of different source groups related to oil and gas development. It is using a photochemical air quality model called the Comprehensive Air Quality Model with Extensions (CAMx) to quantitatively estimate potential impacts to air quality and related values such as visibility, deposition, and lake chemistry in the surrounding area and at nearby Class I and sensitive Class II wilderness areas. Additional details on how the study is being conducted can be found in the CARMMS modeling protocol (*Colorado Air Resource Management Modeling Study (CARMMS), Detailed Descriptions of Background, Emissions Inventories and Air Quality Modeling Methodologies for the Study*, Draft August, 2014).

Emissions inventories were developed for a 2008 base case as well as a 2021 future projection year. CARMMS was run using a conservative estimate of potential development (i.e., the projected level of development is on the high end of what is expected). This is referred to in this discussion as the “2021 high scenario”. The 2021 emissions were derived from the 2020

emissions estimates developed under a different but complementary interagency study known as the Three-State Air Quality Study covering Colorado, Utah, and Wyoming. Those emissions estimates were updated with improved oil and gas and mining emissions estimates for use in the CARMMS analysis⁴⁰. As discussed earlier, this scenario projected a potential for 354 wells to be developed within the larger area bounded by the extent of the PNG. The results from this analysis are disclosed in the Summary of CARMMS - Pawnee Grassland Modeling Results Report (Project File) and summarized here. These results are documented in a draft report dated May 2014 that was provided by BLM on June 3, 2014.

The emissions inventory included all oil and gas sources within the domain, as well as on-road and off-road mobile sources, stationary sources, windblown dust, fires and biogenic emissions, agricultural emissions such as ammonia, and other miscellaneous sources. Estimates of future emissions from potential oil and gas development included emissions from well pad construction and development, production operations and central gas compression and processing. The CARMMS modeling factored in emissions mitigation from federal and state air pollution control regulations that are currently effective or expected to be phased in through 2020.

An emissions inventory was created for the Pawnee NG potential development and analyzed separately as a source group in the CARMMS modeling study. The projected development scenario was based on the RFD developed by oil and gas resource specialists with input from with industry representatives and assumed a constant oil and gas development rate through the year 2021. This emissions scenario considered on-the-books requirements for emissions controls. Current EPA and Colorado emissions controls as of 2013 included New Source Performance Standards contained in 40 CFR Part 60 Subpart OOOO, and the analysis assumed Tier 2⁴¹ drilling and completion engines for oil and gas well development. The estimated inventory for 2021 for PNG area oil and gas development that was used in the CARMMS analysis is shown in Table 48 below.

Table 48 Estimated Emissions from Additional Oil and Gas Development under the 2021 Development Scenario.

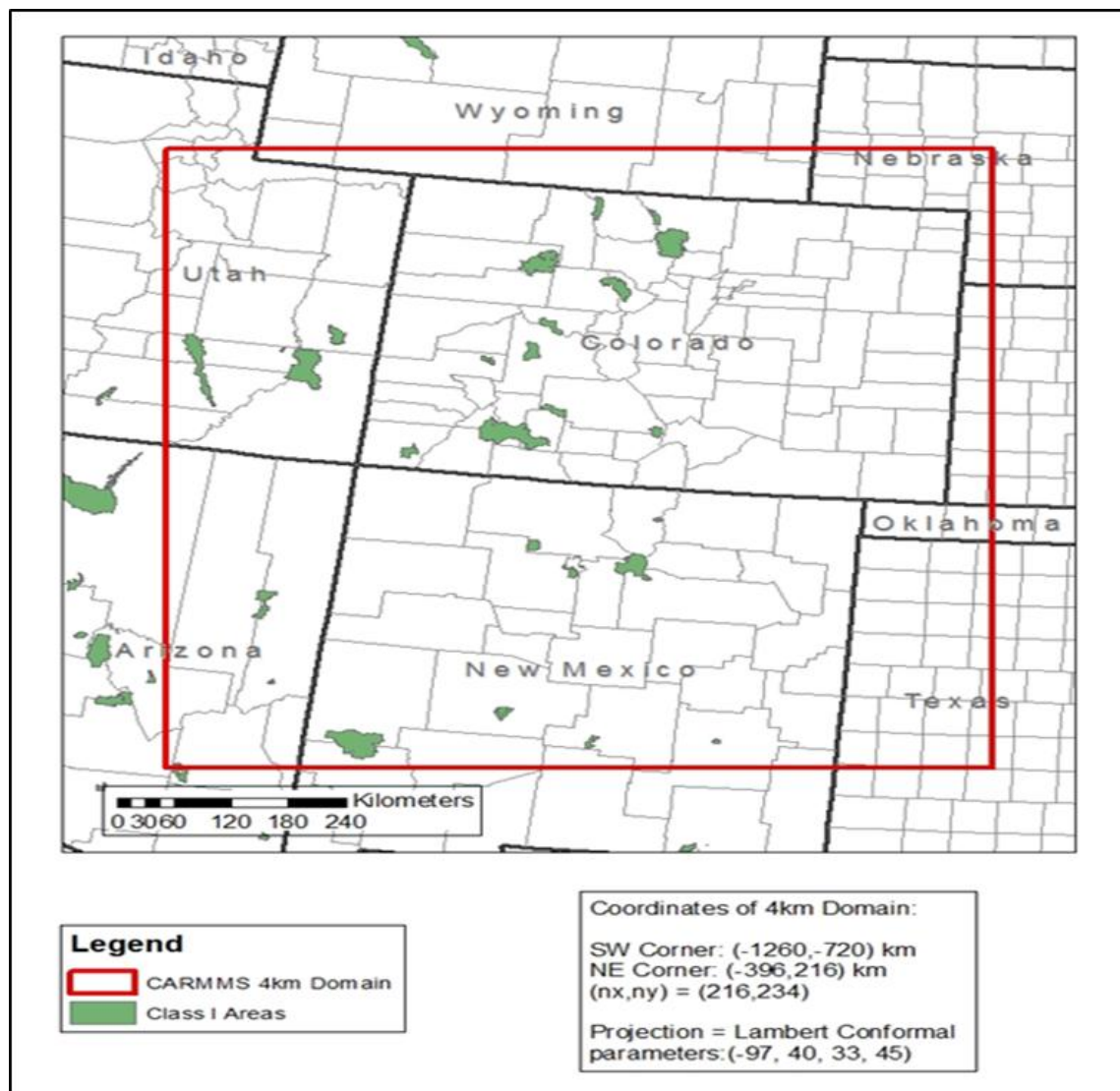
Area	Potential Additional Wells	Additional Oil and Gas Emissions Under Maximum Development Scenario for Alternatives 1, 2 and 3 (tons/year)					
		NO _x	VOC	PM ₁₀	PM _{2.5}	SO ₂	CO
Pawnee National Grasslands--Federal	354	927	1,838	686	89	3	823

⁴⁰ For more information on how the 2021 oil and gas emissions estimates were developed, see the CARMMS protocol, *Colorado Air Resource Management Modeling Study (CARMMS), Detailed Descriptions of Background, Emissions Inventories and Air Quality Modeling Methodologies for the Study, Draft August, 2014*, page 3 and pp. 30-36.

⁴¹ Emissions standards for nonroad diesel engines have been phased in through a tiered approach to reduce emissions from these engines. Higher tier numbers indicate engines meeting stricter emissions standards. For more information, see <http://www.epa.gov/otaq/nonroad-diesel.htm>.

The CARMMS analysis estimated impacts to air quality and related values from the various source groups examined, as well as cumulative impacts from emissions from all sources within the area considered by the model (referred to as the “modeling domain”). The model was run using a set of nested domains with progressively smaller grid cell sizes⁴². Emissions from all sources were included for all three domains. These included a 36 km domain covering the continental US, a 12 km domain covering the entire Rocky Mountain region, and a 4 km domain included the entire state of Colorado, as well as portions of eastern Utah, northeastern Arizona, northern New Mexico, and small portions of Wyoming, Nebraska, Kansas, Oklahoma, and Texas. The following map, Figure 38, shows the CARMMS 4 km air quality modeling domain; this is the area within which effects from oil and gas development were analyzed. Class I areas within the modeling domain for which impacts were assessed are shown in green on the map.

Figure 40 CARMMS Modeling Domain



⁴² The grid cell size of the model determines its resolution. Reducing the grid size improves the model's ability to reproduce differences in concentrations of atmospheric pollutants between adjacent areas.

Air Quality Modeling Results—Impacts from PNG Area Development

The future year modeling (2021) was run for an entire year of 2008 weather research and forecasting meteorological data. Maximum impacts from PNG sources reported by the model could occur at any time during the year. Impacts to NO₂ concentrations due to PNG oil and gas emissions sources (as well as other source groups) were determined using the particulate matter source apportionment tool. This tool treats all reactive gas nitrogen species, including NO, NO₂, NO₃ radical, HONO, and N₂O₅, as a group, so NO₂ impacts resulting from specific source groups (such as the Pawnee NG) cannot be separately identified using the tool. In the FEIS, all reported impacts from Pawnee NG sources to annual NO₂ concentrations included all reactive gas nitrogen compounds and therefore overestimated impacts to NO₂ concentrations.

Since the FEIS was written, additional post-processing of the CARMMS results was completed in order to provide a better estimate of Pawnee NG contributions to NO₂ concentrations. This was done by determining the ratio of NO₂ to reactive gas nitrogen (RGN) concentrations for all cumulative source emissions and applying that NO₂ / RGN ratio to the RGN concentrations for each source group / apportionment area to obtain an estimate of NO₂ in each cell for the separate source apportionment areas (i.e. Pawnee NG). This should provide a reasonable estimate of the NO₂ contributions of Pawnee oil and gas sources in areas near the grasslands as these sources will be the largest contributors to NO₂ concentrations near the Pawnee. In areas further away from the Pawnee NG, where Pawnee oil and gas sources (or other similar oil and gas sources) would have a smaller influence on the overall RGN profile (such as the Denver metropolitan area where there is a substantial contribution from mobile sources), this technique could underestimate the NO₂ fraction of total RGN for the Pawnee sources. The contributions of the Pawnee to the daily maximum 1-hour and annual average NO₂ concentrations presented in this document were estimated using this technique. However, the contributions of the Pawnee to NO₂ PSD increments originally presented in the FEIS were retained here. These values represent total reactive gas nitrogen, and are thus a conservative estimate of contributions to the NO₂ increments.

Impacts of Alternatives 2 and 3 on Criteria Pollutant Concentrations and PSD Increments

Impacts to PSD increments that would result from potential PNG area oil and gas development were estimated as part of the CARMMS analysis. These estimates are shown in Table 49 below. It should be noted that the estimated impacts to increment consumption do not constitute a regulatory increment consumption analysis, but are provided to assess potential contributions to pollutant concentrations as a way to provide a comparison with a common bench mark. A regulatory increment analysis would be conducted by the regulatory authority (the Colorado Air Pollution Control Division) and would consider all increment consuming sources and would be done, when applicable, under the regulatory context of permitting new or modified major stationary sources of air pollution as defined in the CAA. The table shows the highest predicted impacts to PSD increments for any Class I or sensitive Class II area for NO₂, PM₁₀, PM_{2.5}, and SO₂. The annual second-highest values for the 24-hour PM_{2.5} impacts would be lower than those shown here for the highest annual values. All values are less than 1% of the applicable PSD increment.

Table 49 Highest PSD Pollutant Concentrations at any Class I or II Area due to Emissions from PNG Area Oil and Gas Development (units are $\mu\text{g}/\text{m}^3$).

Pollutant	PSD Class I Increment	Max @ any Class I area	Percent of PSD Class I Increment	Class I Area where Max occurred	PSD Class II Increment	Max @ any Class II area	Percent of PSD Class II Increment	Class II Area where Max occurred
Annual NO ₂	2.5	0.0011	0.04%	Rocky_Mountain	25	0.0006	0.00%	Mount_Evans
24-Hour PM ₁₀	8	0.0351	0.44%	Rocky_Mountain	30	0.0121	0.04%	Mount_Evans
Annual PM ₁₀	4	0.0015	0.04%	Rocky_Mountain	17	0.0008	0.00%	Mount_Evans
24-Hour PM _{2.5}	2	0.0179	0.90%	Rocky_Mountain	9	0.0067	0.07%	Mount_Evans
Annual PM _{2.5}	1	0.0006	0.06%	Rocky_Mountain	4	0.0003	0.01%	Mount_Evans
3-Hour SO ₂	25	0.0005	0.00%	Rocky_Mountain	512	0.0002	0.00%	Mount_Evans
24-Hour SO ₂	5	0.0002	0.00%	Rocky_Mountain	91	0.0001	0.00%	Mount_Evans
Annual SO ₂	2	0.0000	0.00%	Rocky_Mountain	20	0.0000	0.00%	Mount_Evans

Impacts from possible PNG oil and gas development to the 1-hour NO₂ standard are shown in Figure 39. The maximum modeled impact to the 8th-highest 1-hour NO₂ concentration from PNG sources is 7 mg/m^3 . Impacts to the annual average NO₂ concentration are shown in Figure 39. The maximum modeled impact to the annual average NO₂ concentration from PNG sources is 2 mg/m^3 .

Figure 41 Maximum Modeled Contributions to 1 Hour Daily Maximum NO₂ Concentrations from PNG 2021 Development Scenario.

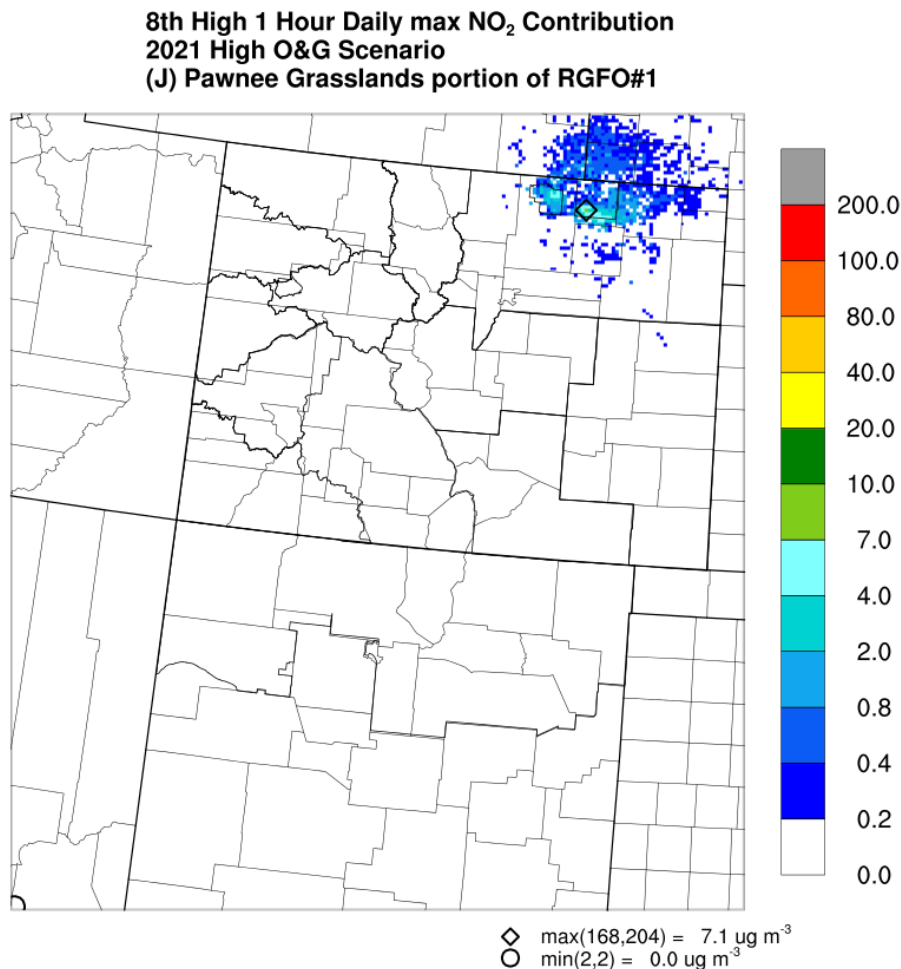
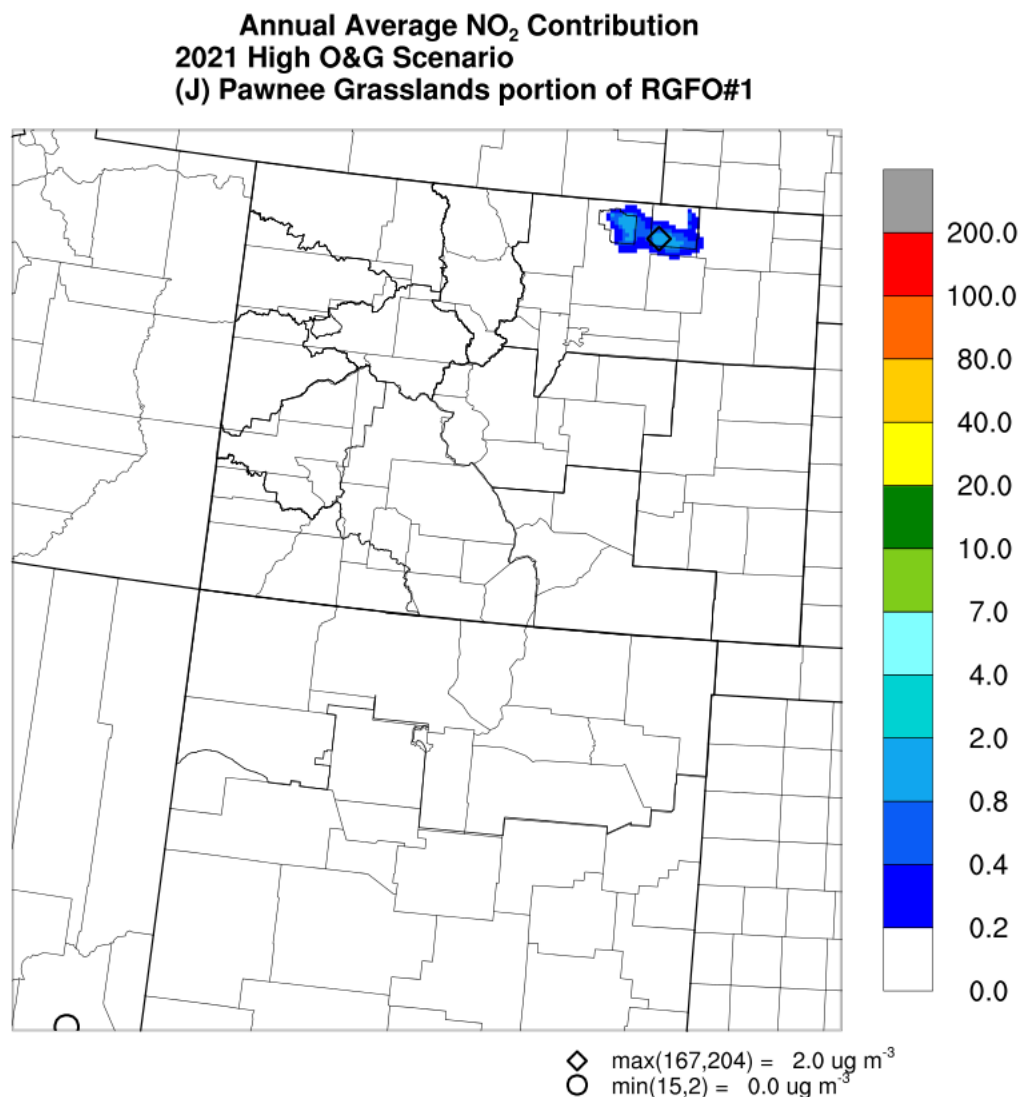


Figure 42 Maximum Modeled Contributions to Annual Average NO₂ Concentrations from PNG 2021 Development Scenario.



Impacts from possible PNG oil and gas development to the 1-hour SO₂ standard are shown in Figure 41. The maximum modeled impact to the 4th-highest daily maximum 1-hour SO₂ concentration from PNG sources is 0 mg/m³. Impacts to the annual average SO₂ concentration are shown in Figure 42. The maximum modeled impact to the annual average SO₂ concentration from PNG sources is 0 mg/m³.

Figure 43 Maximum Modeled Contributions to 1 Hour Daily Maximum SO₂ Concentrations from PNG 2021 Development Scenario

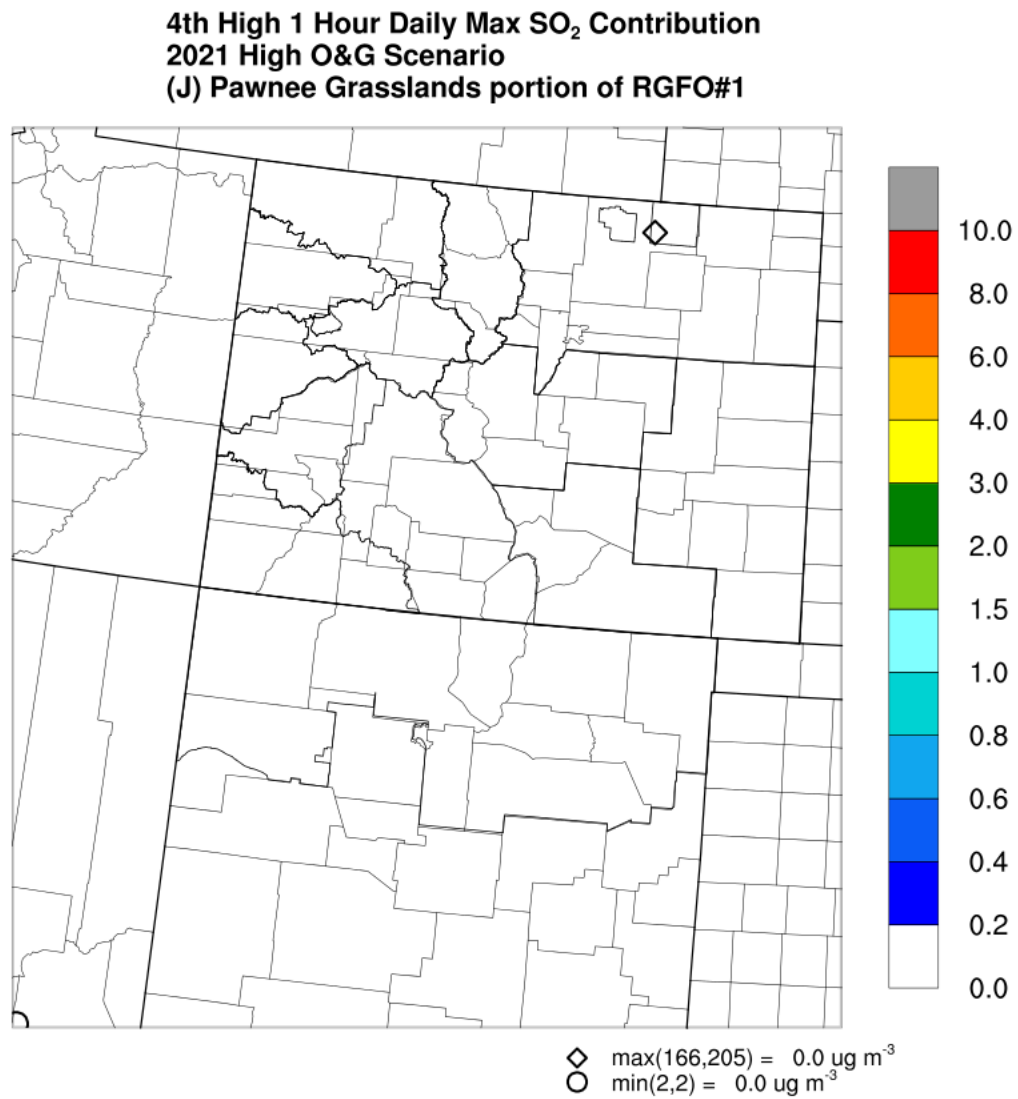
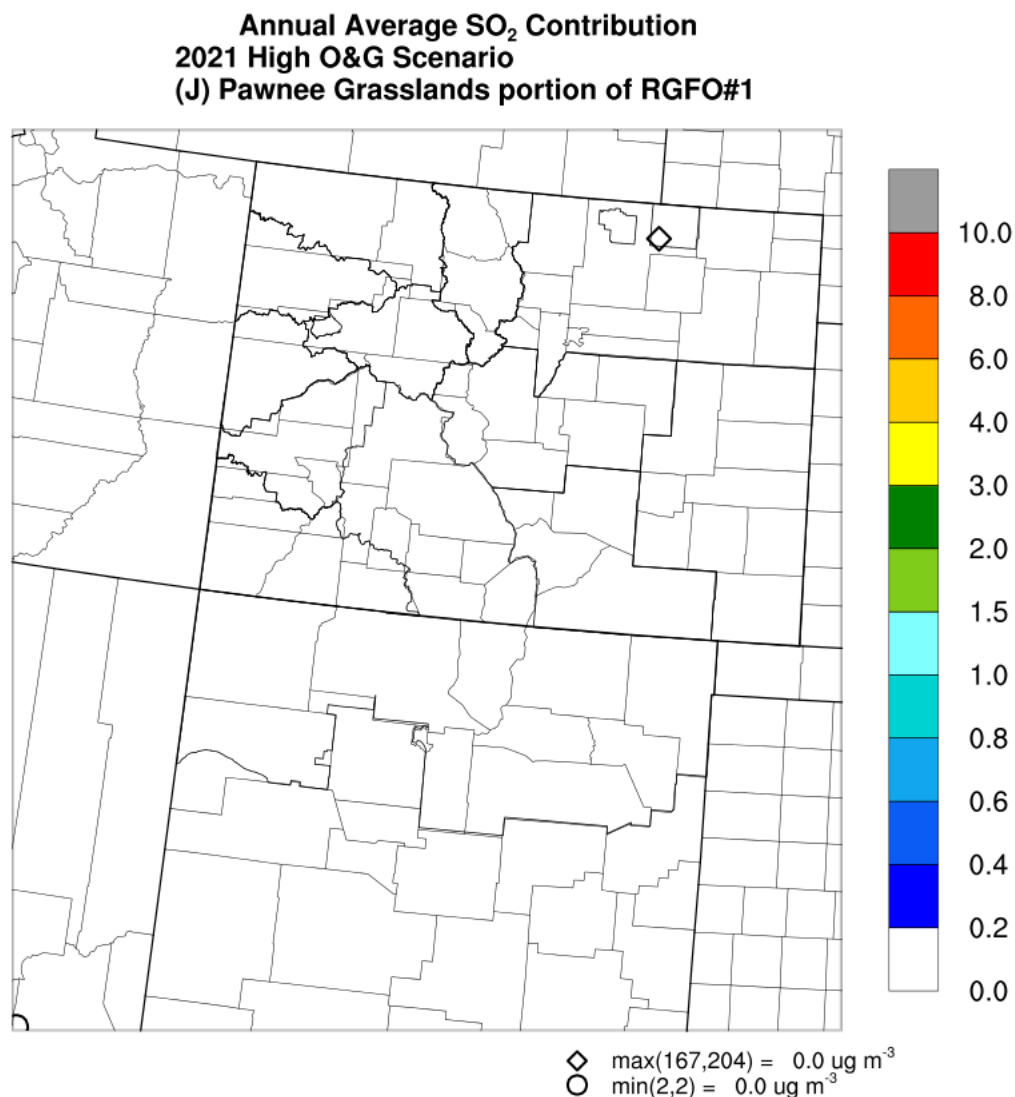


Figure 44 Maximum Modeled Contributions to Annual Average SO₂ Concentrations from PNG 2021 Development Scenario



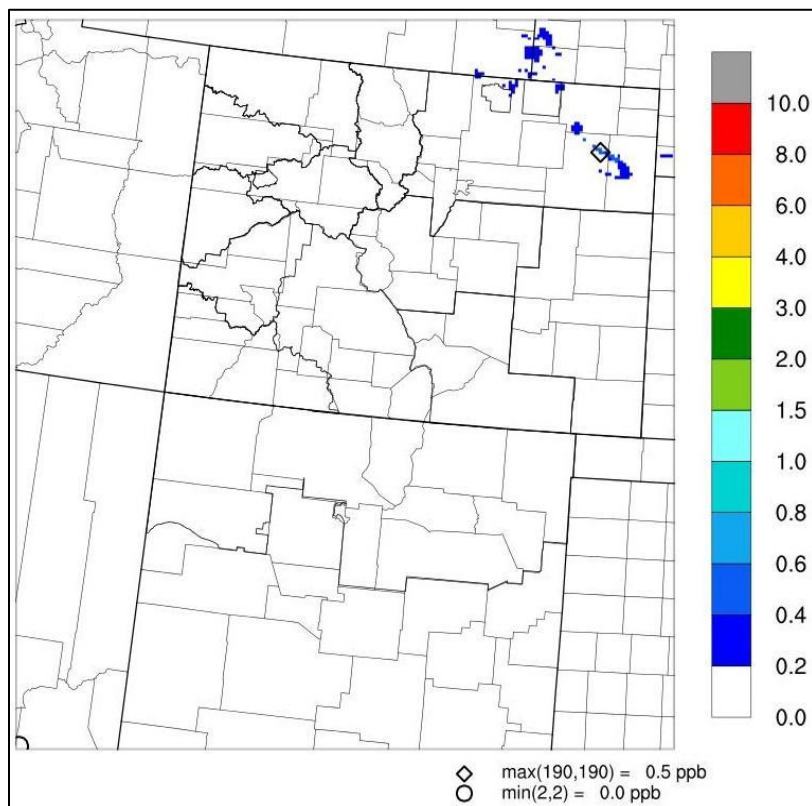
The 1-hour NO₂ and 1-hour SO₂ standards are unlikely to be exceeded except in areas very close to a source or group of sources. Impacts from potential oil and gas development will be evaluated if needed as part of a near-field analysis at the project level. For this analysis, no projects are proposed and the locations of potential developments cannot be determined, making it infeasible to perform an analysis of near-field impacts. Impacts to these standards in the immediate vicinity of development will be assessed if needed as part of a near-field analysis at the project level.

Modeled contributions to the 2nd highest 1-hour daily maximum and annual 2nd-highest 8-hour CO concentrations from possible PNG oil and gas development are not available. Impacts to these standards in the immediate vicinity of development will be assessed if needed as part of a near-field analysis at the project level.

The maximum modeled contribution from Pawnee NG sources to SO₂ 3-hour and 24-hour concentrations at any grid cell within the modeling domain was less than 1 µg/m³. The maximum contributions to the 8th highest 24-hour and annual PM_{2.5} concentrations due to emissions from Pawnee NG sources are 0.6 and 0.2 µg/m³, respectively. The maximum contribution to the 2nd highest 24-hour PM₁₀ from Pawnee NG sources is 3 µg/m³.

The CARMMS analysis also projected the impacts of Pawnee NG area emissions from potential oil and gas development on ozone concentrations. The CARMMS 2008 base case results indicate that 4th highest daily maximum ozone concentrations within the project area (Weld County) would range from 70-73 ppb, which is very close to the standard and agrees reasonably well with actual monitored values. The CARMMS results for the 2021 reasonably foreseeable development scenario show a mixture of slight increases and decreases in ozone concentrations when compared with 2008 concentrations within the project area. The maximum modeled contributions from potential future Pawnee area development are shown below in Figure 43. For the 2021 scenario, the maximum modelled impact of these emissions to ozone concentrations anywhere in the domain was 0.5 ppb (see Figure 43). The highest modelled contribution from Pawnee area sources to a modeled exceedance of the 8-hour ozone was 0.032 ppb in the Denver area. Modeled contributions to areas in northern New Mexico and eastern Utah, where exceedances are projected to occur, were negligible.

Figure 45 Maximum Modeled Contributions to Ozone Concentrations from PNG 2021 Development Scenario.



As shown in Figure 43, maximum contributions to ozone contributions from PNG oil and gas development are not expected to be more than 0.4 ppb. The geographical extent of the

contributions is limited to the north-eastern part of the Colorado Front Range and southern Wyoming.

Visibility Impacts

Visibility impacts were calculated at all Class I and sensitive Class II wilderness areas using the 2010 Federal Land Managers' Air Quality Related Values Work Group (FLAG) Report procedures using monthly average relative humidity adjustment factors and annual average natural conditions. The FLAG report details the federal lands managers' guidance for assessing impacts to air quality related values, including visibility, in lands that they manage.

The 2010 FLAG report states that a source whose 98th percentile value of the haze index is greater than 0.5 deciview (dv) (approximately 5% change in light extinction) is considered to contribute to regional haze visibility impairment, and a source that exceeds 1.0 dv (approximately 10% change in light extinction) causes visibility impairment. The model-predicted impacts from Pawnee NG oil and gas sources were compared against the 0.5 and 1.0 change in deciview (Δdv) thresholds. As shown in Table 50, below, the results indicate that the maximum impacts to visibility at Class I and sensitive Class II wilderness areas within the modeling domain were 0.13 dv at Rocky Mountain National Park, and 0.056 dv at the Mount Evans wilderness. There were no days of visibility impacts above 0.5 dv at any Class I or sensitive Class II wilderness area within the modeling domain.

Table 50 Maximum Pawnee NG Impacts to Visibility (dv)

Max dv @ Class I	Class I (Max Occurs)	Max dv @ Class II	Class II (Max Occurs)
0.1306	CI_Rocky_Mountain	0.0558	CII_Mount_Evans

Deposition Impacts

The contributions of emissions from Pawnee NG oil and gas development under the 2021 scenario to sulfur and nitrogen deposition at Class I and II areas are shown in Table 46. These annual deposition amounts are compared against the 0.005 kilogram per hectare per year (kg/ha/yr) deposition analysis threshold (DAT) adopted by federal land managers. A DAT is defined as the additional amount of nitrogen or sulfur deposition below which estimated impacts to a Class I area, from a proposed new or modified major emission source, are considered negligible (FLAG 2010). An impact above this threshold does not necessarily indicate significance, but it highlights the need for further study of a proposal's potential to adversely impact sensitive resources such as soils, vegetation, or aquatic systems. Tables 51 and 52 show the highest PNG contributions to nitrogen and sulfur deposition for the maximum and average across grid cells that cover the Class I and sensitive Class II wilderness areas. For both pollutants, the highest deposition at a Class I area occurs at Rocky Mountain National Park. The highest deposition at a sensitive Class II wilderness area occurs at the Mount Evans and Lost Creek wilderness areas. None of the 30 Class I areas have modeled annual nitrogen or sulfur deposition that exceeds the DAT.

Table 51 Highest Maximum and Average Nitrogen Deposition Impacts Under 2021 Scenario (kg/ha/yr.) from Pawnee NG Oil and Gas Development

Analysis Type	Dep @ Class I Area	Class I Area where Dep occurred	Dep @ Class II Area	Class II Area where Dep occurred
Maximum	0.0017	CI_Rocky_Mountain	0.0013	CII_Mount_Evans
Average	0.0006	CI_Rocky_Mountain	0.0007	CII_Lost_Creek

Table 52 Highest Maximum and Average Sulfur Deposition Impacts Under 2021 Scenario (kg/ha/yr.) from Pawnee NG Oil and Gas Development

Analysis Type	Dep @ Class I Area (kg/ha/yr.)	Affected Class I Area	Dep @ Class II Area (kg/ha/yr.)	Affected Class II Area
Maximum	0.000018	Rocky Mountain NP	0.000017	Lost Creek and Mount Evans Wilderness Areas
Average	0.000006	Rocky Mountain NP	0.000008	Lost Creek and Mount Evans Wilderness Areas

Impacts to Acid Neutralizing Capacity (ANC) At Sensitive Lakes

Many headwater lakes located in wilderness areas are sensitive to acid deposition. A lake's acid neutralizing capacity governs its ability to tolerate elevated acidic inputs from the atmosphere—the lower the ANC, the lower the lake's ability to neutralize acidic inputs. This analysis assessed the impacts of sulfur and nitrogen deposition on ANC for 58 lakes located in Class I areas and sensitive Class II wilderness areas within the domain. Lakes were chosen for this analysis based on their relatively low baseline ANC values.

The USFS has established levels of acceptable change to ANC for sensitive lakes. For lakes with a base ANC > 25 micro equivalents per liter (µeq/l), the limit is no greater than a 25% change (decrease) in ANC. For lakes with a baseline ANC < 25 µeq/l, the limit is no greater than a 1 µeq/l change (decrease) in ANC. The projected changes in ANC due to nitrogen and sulfur deposition from the Pawnee NG 2021 High Scenario are shown in Table 53 below. The changes shown in the table are absolute values and represent projected decreases in ANC. The largest projected change, a decrease of 0.0064 µeq/l, is for Upper Middle Beartracks Lake in the Mount Evans Wilderness. The greatest projected decrease on a percentage basis is 0.02% at Blue Lake in the Indian Peaks Wilderness. Also shown in the table are the 10th percentile lowest ANC (which is used to determine the baseline), the projected total sulfur (S) and nitrogen (N) deposition in kg/ha/yr., the estimated annual precipitation, the limit of acceptable change, and the predicted value of the 10th percentile lowest ANC for the lake in 2021. All of the values are below the USFS limit of acceptable change threshold at all sensitive lakes.

Table 53 Projected Changes in Acid Neutralizing Capacity at Sensitive Lakes Due to Federal Oil and Gas Development Within the Pawnee NG Planning Area.

Pawnee Grasslands portion of RGFO#1									
Lake	10th Percentile Lowest ANC Value (µeq/L)	Total S Dep (kg-S/ha-yr)	Total N Dep (kg-N/ha-yr)	PPT (m)	Delta ANC (%) [*]	Delta ANC (µeq/L) [*]	USFS LAC Threshold	Below Threshold?	2021 Hi Predicted 10th Percentile Lowest ANC Value (µeq/L)
Brooklyn Lake	101.7	0.0000	0.0000	0.898	0.00%	0.0005	<10%	yes	101.7
Tabor Lake	112.4	0.0000	0.0000	0.860	0.00%	0.0005	<10%	yes	112.4
Booth Lake	86.8	0.0000	0.0001	0.844	0.00%	0.0006	<10%	yes	86.8
Upper Willow Lake	134.1	0.0000	0.0001	0.741	0.00%	0.0015	<10%	yes	134.1
Ned Wilson Lake	39.0	0.0000	0.0000	1.158	0.00%	0.0001	<10%	yes	39.0
Upper Ned Wilson Lake	12.9	0.0000	0.0000	1.158	0.00%	0.0001	<1(µeq/L)	yes	12.9
Lower NWL Packtrail Pothole	29.7	0.0000	0.0000	1.158	0.00%	0.0001	<10%	yes	29.6
Upper NWL Packtrail Pothole	48.7	0.0000	0.0000	1.158	0.00%	0.0001	<10%	yes	48.7
Walk Up Lake	55.2	0.0000	0.0000	0.878	0.00%	0.0000	<10%	yes	55.2
Bluebell Lake	55.5	0.0000	0.0000	0.883	0.00%	0.0000	<10%	yes	55.5
Dean Lake	48.9	0.0000	0.0000	1.061	0.00%	0.0000	<10%	yes	48.9
No Name (Utah, Duchesne - 4D2-039)	67.0	0.0000	0.0000	0.844	0.00%	0.0000	<10%	yes	67.0
Upper Coffin Lake	64.9	0.0000	0.0000	0.960	0.00%	0.0000	<10%	yes	64.8
Fish Lake	105.8	0.0000	0.0000	0.869	0.00%	0.0000	<10%	yes	105.8
Blodgett Lake, Colorado	47.7	0.0000	0.0000	0.928	0.00%	0.0003	<10%	yes	47.7
Upper Turquoise Lake	104.0	0.0000	0.0000	0.809	0.00%	0.0005	<10%	yes	104.0
Upper West Tennessee Lake	114.2	0.0000	0.0000	0.904	0.00%	0.0006	<10%	yes	114.2
Blue Lake (Colorado; Boulder - 4E1-040)	19.3	0.0000	0.0003	1.128	0.02%	0.0032	<1(µeq/L)	yes	19.2
Crater Lake	53.1	0.0000	0.0003	1.071	0.01%	0.0027	<10%	yes	53.1
King Lake (Colorado; Grand - 4E1-049)	52.3	0.0000	0.0004	0.959	0.01%	0.0042	<10%	yes	52.3
No Name Lake (Colorado; Boulder - 4E1-055)	25.6	0.0000	0.0005	1.126	0.02%	0.0044	<10%	yes	25.6
Upper Lake	69.0	0.0000	0.0003	1.139	0.00%	0.0024	<10%	yes	69.0
Small Lake Above U-Shaped Lake	59.9	0.0000	0.0000	0.927	0.00%	0.0004	<10%	yes	59.9
U-Shaped Lake	81.4	0.0000	0.0000	0.927	0.00%	0.0004	<10%	yes	81.4
Avalanche Lake	158.8	0.0000	0.0000	1.282	0.00%	0.0001	<10%	yes	158.8
Capitol Lake	154.4	0.0000	0.0000	1.110	0.00%	0.0002	<10%	yes	154.4
Moon Lake (Upper)	53.0	0.0000	0.0000	1.110	0.00%	0.0002	<10%	yes	53.0
Upper Middle Beartrack Lake	50.9	0.0000	0.0005	0.869	0.01%	0.0064	<10%	yes	50.9
Abyss Lake	81.1	0.0000	0.0004	0.896	0.01%	0.0044	<10%	yes	81.1
Frozen Lake	93.3	0.0000	0.0004	0.896	0.00%	0.0044	<10%	yes	93.3
North Lake	80.9	0.0000	0.0004	0.896	0.01%	0.0044	<10%	yes	80.9
South Lake	66.7	0.0000	0.0004	0.896	0.01%	0.0044	<10%	yes	66.7
Lake Elbert	56.6	0.0000	0.0000	1.726	0.00%	0.0002	<10%	yes	56.6
Seven Lakes (LG East)	36.2	0.0000	0.0000	1.546	0.00%	0.0002	<10%	yes	36.2
Summit Lake	48.0	0.0000	0.0000	1.449	0.00%	0.0002	<10%	yes	48.0
Deep Creek Lake	20.6	0.0000	0.0000	0.887	0.00%	0.0002	<1(µeq/L)	yes	20.6
Island Lake	71.0	0.0000	0.0001	1.079	0.00%	0.0012	<10%	yes	71.0
Kelly Lake	179.9	0.0000	0.0001	1.079	0.00%	0.0012	<10%	yes	179.8
Rawah Lake #4	41.3	0.0000	0.0002	1.098	0.00%	0.0015	<10%	yes	41.3
Crater Lake (Sangre de Cristo)	162.9	0.0000	0.0002	0.959	0.00%	0.0024	<10%	yes	162.9
Lower Stout Lake	145.2	0.0000	0.0003	0.671	0.00%	0.0042	<10%	yes	145.2
Upper Little Sand Creek Lake	129.5	0.0000	0.0002	1.064	0.00%	0.0025	<10%	yes	129.5
Upper Stout Lake	76.3	0.0000	0.0003	0.671	0.01%	0.0042	<10%	yes	76.3
Glacier Lake (Colorado)	63.4	0.0000	0.0001	1.145	0.00%	0.0005	<10%	yes	63.4
Lake South of Blue Lakes	16.9	0.0000	0.0001	1.312	0.00%	0.0005	<1(µeq/L)	yes	16.9
Big Eldorado Lake	19.6	0.0000	0.0000	1.128	0.00%	0.0001	<1(µeq/L)	yes	19.6
Four Mile Pothole	123.4	0.0000	0.0000	1.173	0.00%	0.0003	<10%	yes	123.4
Lake Due South of Ute Lake	13.2	0.0000	0.0000	1.067	0.00%	0.0001	<1(µeq/L)	yes	13.2
Little Eldorado	-3.3	0.0000	0.0000	1.128	0.00%	0.0001	<1(µeq/L)	yes	-3.3
Little Granite Lake	80.7	0.0000	0.0000	0.830	0.00%	0.0003	<10%	yes	80.7
Lower Sunlight Lake	80.9	0.0000	0.0000	1.177	0.00%	0.0001	<10%	yes	80.9
Middle Ute Lake	42.8	0.0000	0.0000	1.052	0.00%	0.0001	<10%	yes	42.8
Small Pond Above Trout Lake	25.5	0.0000	0.0000	1.087	0.00%	0.0003	<10%	yes	25.5
Upper Grizzly Lake	29.9	0.0000	0.0000	1.177	0.00%	0.0001	<10%	yes	29.9
Upper Sunlight Lake	28.0	0.0000	0.0000	1.177	0.00%	0.0001	<10%	yes	28.0
West Snowdon Lake	39.4	0.0000	0.0000	0.978	0.00%	0.0001	<10%	yes	39.3
White Dome Lake	2.1	0.0000	0.0000	1.128	0.01%	0.0001	<1(µeq/L)	yes	2.1
South Golden Lake	111.4	0.0000	0.0000	0.984	0.00%	0.0002	<10%	yes	111.4

^{*} USDA Forest Service methodology reports both Delta ANC calculations and LAC thresholds as positive quantities, however they reflect a decrease in lake ANC

Figure 44 shows the projected cumulative impacts to the 4th highest daily maximum 8-hour ozone concentration at locations throughout the modeling domain. The projected values are the maximum predicted for each location and would not necessarily occur on the same day. Areas colored in white are those with a projected maximum value at or above 76 ppb, indicating a projected exceedance of the standard. Other colors represent areas with projected maximum values at or below the standard of 75 ppb. The projected values for the 2008 base case are shown on the map on the left side of the figure. The map on the right shows projected values for the 2021 high development scenario. The modeling analysis predicts exceedances of the ozone standard in some areas, particularly in the Front Range urban area, which is consistent with monitoring results. The model predicts some increases and some decreases by 2021 in the 4th highest daily maximum 8-hour ozone concentration for difference areas on the map, but the overall extent of exceedances is predicted to decrease, particularly in the Denver area.

The 4th highest 8 hour average daily max O₃
2008
CARMMS CAMx 4km

◇ max(123,86) = 78.0 ppb
○ min(144,185) = 63.2 ppb

The 4th highest 8 hour average daily max O₃
2021 High Oil and Gas Scenario
CARMMS CAMx 4km

◇ max(48,201) = 78.0 ppb
○ min(13,62) = 55.5 ppb

In addition to absolute modeling results presented above, the cumulative impacts on ozone concentrations were assessed using EPA's Model Attainment Test Software, or MATS (http://www.epa.gov/scram001/modelingapps_mats.htm), as recommended by EPA (2007). This tool was used to take the relative differences in predicted ozone between the 2008 base case and the 2021 high development scenario and apply them to measured ozone concentrations to estimate future ozone design values at monitoring locations.

A design value is a statistic that describes the air quality status of a given location relative to the level of the National Ambient Air Quality Standards. For ozone, this is the 3-year average of the

annual 4th-highest 8-hour ozone concentration. The MATS tool was also used to make 2021 ozone design value predictions at locations throughout the modeling domain through the unmonitored area analysis procedures. The results of this analysis are shown in Figure 45 below for selected monitors located within the Denver nonattainment area. The figure shows the monitor name, EPA identifier (CID), the current design value (DVC), and the future predicted design value (DVF). For most of the monitored locations, modeled ozone predictions within the entire domain result in lower future modeled values, with the only exception being the Larimer monitor (within the Denver-Northern Front Range Ozone nonattainment area), which registered a slight increase from the baseline year to the future year (2021). Only two monitors within the entire domain showed future design values that would exceed the 8 hour-ozone standard in year 2021. Predicted future design values for all of the rest of the monitored locations were below the standard.

Figure 47 Baseline and Predicted Future Design Values for Ozone (ppb) Results from the Modeled Attainment Test Software Relative Analysis

Monitor Name	CID	DVC	DVF 2021 RFD High
CO_Adams	080013001	71.5	70.5
CO_Boulder	080130011	77.3	74.4
CO_Denver	080310014	70.3	69.0
CO_Douglas	080350004	78.3	75.7
CO_Jefferson	080590006	82.0	79.5
CO_Jefferson	080590011	76.3	74.0
CO_Larimer	080690011	78.0	78.9
CO_Larimer	080691004	67.3	67.4
CO_Weld	081230009	72.7	72.1

* DVC; based on 2006-2010 observations

Cumulative Impacts to Visibility at Class I Areas

The EPA promulgated the Regional Haze Rule to meet the Clean Air Act's goal of the "prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I federal areas which impairment results from man-made air pollution." Under this rule, states track trends in visibility conditions on the 20% of days with the best visibility (20% clearest days) and on the 20% of days with the poorest visibility (20% haziest days). For the cumulative visibility analysis, visibility impacts were calculated on both the 20% clearest and 20% haziest days at Class I areas within the modeling domain using the MATS software. These results are presented in Table 54 below. The table shows the projected 2008 base case deciview on the clearest and haziest days and the corresponding projections for the 2021 scenario. The change for both scenarios is also shown, where a decrease in deciview indicates improving visibility. The modeling results suggest that on the haziest days, visibility will improve at all Class I areas except for Salt Creek and Capitol Reef. On the clearest days, small increases in deciview are projected for a number of Class I areas, but only Bandelier National Monument, Capitol Reef National Park, and Salt Creek show a degradation of visibility on the clearest days

of more than 0.5 deciview. No change in visibility of more than 0.7 dv is projected on the best days at any Class I area. For comparison, the Federal Land Managers' Air Quality Related Values Work Group considers a source whose 98th percentile value of the haze index is greater than 0.5 deciview (dv) (approximately a 5% change in light extinction) to be contributing to regional haze visibility impairment. Similarly, a source that exceeds 1.0 dv change (approximately a 10% change in light extinction) causes visibility impairment.⁴³

Table 54 Projected Cumulative Impacts to Visibility in Class I Areas

Class I Area		IMPROVE Monitor	Haziest 20% of Days (dv)			Clearest 20% of Days (dv)		
			2008 Base Case	2021 Scenario	Deciview Change	2008 Base Case	2021 Scenario	Deciview Change
Arches NP	UT	CANY1	11.02	10.63	-0.39	2.86	2.97	0.11
Mount Baldy Wilderness	AZ	BALD1	11.10	10.40	-0.70	2.86	2.83	-0.03
Bandelier NM	NM	BAND1	11.33	11.16	-0.17	4.01	4.71	0.70
Black Canyon of the Gunnison NM	CO	WEMI1	9.95	9.52	-0.43	2.25	2.39	0.14
Bosque del Apache	NM	BOAP1	12.72	12.26	-0.46	5.50	5.52	0.02
Canyonlands NP	UT	CANY1	11.02	10.63	-0.39	2.86	2.97	0.11
Capitol Reef NP	UT	CAPI1	10.72	11.00	0.28	2.58	3.09	0.51
Eagles Nest Wilderness	CO	WHRI1	8.68	8.07	-0.61	0.69	0.65	-0.04
Flat Tops Wilderness	CO	WHRI1	8.68	8.07	-0.61	0.69	0.65	-0.04
Gila Wilderness	NM	GICL1	11.58	11.13	-0.45	2.58	2.62	0.04
Great Sand Dunes NP	CO	GRSA1	10.90	10.48	-0.42	3.58	3.64	0.06
La Garita Wilderness	CO	WEMI1	9.95	9.52	-0.43	2.25	2.39	0.14
Maroon Bells-Snowmass Wilderness	CO	WHRI1	8.68	8.07	-0.61	0.69	0.65	-0.04
Mesa Verde NP	CO	MEVE1	11.20	10.84	-0.36	3.12	3.18	0.06
Mount Zirkel Wilderness	CO	MOZI1	9.36	8.52	-0.84	0.95	0.75	-0.20
Petrified Forest NP	AZ	PEFO1	12.49	12.19	-0.30	4.54	4.70	0.16
Rawah Wilderness	CO	MOZI1	9.36	8.52	-0.84	0.95	0.75	-0.20
Rocky Mountain NP	CO	ROMO1	12.04	11.18	-0.86	1.91	2.00	0.09
Salt Creek Wilderness	NM	SACR1	16.87	17.38	0.51	6.81	7.32	0.51
San Pedro Parks Wilderness	NM	SAPE1	9.43	8.72	-0.71	1.28	1.32	0.04
West Elk Wilderness	CO	WHRI1	8.68	8.07	-0.61	0.69	0.65	-0.04
Weminuche Wilderness	CO	WEMI1	9.95	9.52	-0.43	2.25	2.39	0.14
White Mountain Wilderness	NM	WHIT1	12.92	12.83	-0.09	3.33	3.43	0.10

Cumulative Impacts to Deposition

The CAMx model used in the CARMMS analysis predicted CAMx-predicted wet and dry fluxes of sulfur- and nitrogen-containing species were processed to estimate total annual sulfur (S) and nitrogen (N) deposition values at each Class I and sensitive Class II wilderness area. Tables 55

⁴³ Federal Land Managers' Air Quality Related Values Work Group (FLAG) Phase I Report—Revised (2010), http://www.nature.nps.gov/air/pubs/pdf/flag/FLAG_2010.pdf

and 56 present the maximum and average deposition values for nitrogen and sulfur under the 2021 high development scenario due to all sources at Class I and sensitive Class II wilderness areas within the modeling domain. The highest predicted maximum nitrogen deposition at a Class I area is 8.5 kg-N/ha/yr. at Bandelier National Monument in New Mexico. The highest average predicted nitrogen deposition at a Class I area is 3.3 kg-N/ha/yr. at Mount Zirkel Wilderness in Colorado. The maximum predicted nitrogen deposition at Rocky Mountain National Park is 3.4 kg-N/ha/yr., and the average is 3.6 kg-N/ha/yr. Predicted sulfur deposition values were lower, with the highest maximum value of 1.74 kg-S/ha/yr. at Mount Baldy Wilderness. The highest average sulfur deposition at a Class I area is 1.2 kg-S/ha/yr. at Wheeler Peak Wilderness.

Table 55 Cumulative Deposition at Class I Areas for 2021 High Development Scenario

Class I Area	Nitrogen- Max	Nitrogen- Avg	Sulfur- Max	Sulfur- Avg
	(kg-N/ha)	(kg-N/ha)	(kg-S/ha)	(kg-S/ha)
Arches NP	1.67	1.56	0.22	0.20
Bandelier NM	8.47	2.29	0.77	0.45
Black Canyon of the Gunnison NM	2.67	2.06	0.36	0.32
Bosque del Apache (Chupadera Unit) Wilderness	1.75	1.60	0.38	0.36
Bosque del Apache (Indian Well Unit) Wilderness	1.87	1.69	0.37	0.35
Bosque del Apache (Little San Pascual Unit) Wilderness	2.49	1.63	0.37	0.35
Bosque del Apache National Wildlife Refuge	2.49	1.71	0.38	0.34
Canyonlands NP	1.81	1.42	0.35	0.22
Capitol Reef NP	3.22	1.55	0.40	0.22
Eagles Nest Wilderness	2.79	2.12	0.92	0.58
Flat Tops Wilderness	3.00	2.39	1.04	0.71
Galiuro Wilderness	2.39	2.29	1.31	1.17
Gila Wilderness	2.07	1.40	1.32	0.63
Great Sand Dunes NM	4.34	2.08	0.57	0.34
La Garita Wilderness	1.97	1.67	0.67	0.51
Maroon Bells-Snowmass Wilderness	3.01	2.45	1.14	0.89
Mesa Verde NP	2.92	2.53	0.58	0.49
Mount Baldy Wilderness	2.38	1.94	1.74	1.13
Mount Zirkel Wilderness	4.29	3.34	1.48	1.04
Pecos Wilderness	2.98	2.29	1.42	0.86
Petrified Forest NP	1.85	1.69	0.52	0.47
Rawah Wilderness	3.23	2.70	1.01	0.73
Rocky Mountain NP	3.41	2.57	1.11	0.68
Salt Creek Wilderness	2.70	2.42	0.69	0.61
San Pedro Parks Wilderness	2.70	2.31	1.11	0.75
Weminuche Wilderness	3.03	2.23	1.50	0.87
West Elk Wilderness	2.55	2.03	0.90	0.58
Wheeler Peak Wilderness	3.10	2.76	1.54	1.22

White Mountain Wilderness	3.09	2.43	1.61	0.98
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Table 56 Cumulative Deposition at Class II Areas for 2021 High Development Scenario

Class II Area	Nitrogen-Max	Nitrogen-Avg	Sulfur-Max	Sulfur-Avg
	(kg-N/ha)	(kg-N/ha)	(kg-S/ha)	(kg-S/ha)
Browns Park NWR	2.33	2.02	0.30	0.25
Colorado NM	2.87	2.38	0.38	0.30
Dinosaur NM	3.70	2.41	0.54	0.35
Dinosaur NM on Colorado side	3.07	2.28	0.54	0.35
Dinosaur NM on Utah side	3.70	2.77	0.53	0.35
Flaming Gorge RA	3.43	2.07	0.46	0.30
Greenhorn Mountains WA	2.76	2.33	0.91	0.57
High Uintas WA	2.38	1.87	0.67	0.49
Holy Cross Wild/San Isabel NF	2.33	1.99	0.74	0.52
Holy Cross Wild/White River NF	2.68	2.06	0.92	0.60
Hunter-Fryingpan Wild/White River NF	2.27	1.97	0.72	0.57
La Garita Wild/Gunnison NF	1.97	1.56	0.67	0.44
La Garita Wild/Rio Grande NF	1.90	1.63	0.63	0.49
Lost Creek WA	2.79	2.34	0.71	0.51
Maroon Bells-Snowmass Wild/Gunnison NF	2.53	2.18	1.00	0.79
Maroon Bells-Snowmass Wild/White River NF	3.01	2.21	1.14	0.71
Mount Zirkel Wild/Routt NF	4.29	3.20	1.48	0.97
Mount Evans WA	3.16	2.35	0.76	0.53
Raggeds Wild/Gunnison NF	2.70	2.25	1.10	0.70
Raggeds Wild/White River NF	2.70	2.52	1.10	0.88
Rawah Wild/Roosevelt NF	3.23	2.51	1.01	0.65
Savage Run WA	2.60	2.16	0.72	0.52
Spanish Peaks WA	2.81	2.49	0.86	0.69
Weminuche Wild/Rio Grande NF	2.83	1.93	1.15	0.66
Weminuche Wild/San Juan NF	3.03	2.36	1.50	0.95
West Elk Wild/Gunnison NF	2.58	1.99	0.90	0.54
White River NF	2.44	2.44	0.70	0.70

Cumulative Impacts to Particulate Matter Concentrations

There are two fine particulate (PM_{2.5}) ambient air quality standards, one for a 24-hour averaging time that is expressed as a three-year average of the 98th percentile value in a year with a threshold of 35 µg/m³, and an annual average over three-years with a threshold of 12 µg/m³. With a complete year of modeling results, the 98th percentile corresponds to the 8th highest daily PM_{2.5} concentration in a year. Figure 46 below shows predicted values for the 8th highest daily average PM_{2.5} concentration for the 2008 base case and the 2021 high scenario across the modeling domain. White shading indicates areas that are projected to exceed the 24-hour standard. The maximum 8th high 24-hour PM_{2.5} in 2008 (670 µg/m³) and 2021 (671 µg/m³)

exceed the $35 \mu\text{g}/\text{m}^3$ NAAQS. These high values occurred on the southern border of the CARMMS domain and were due to emissions from wildfires. Within Colorado, the results show areas along and east of the Front Range are predicted to exceed the standard, and the area experiencing exceedances is projected to grow by 2021.

Figure 48 Eighth highest 24-hour PM_{2.5} Concentrations for the 2008 Base Case (left) and the 2021 High Development Scenario (right).

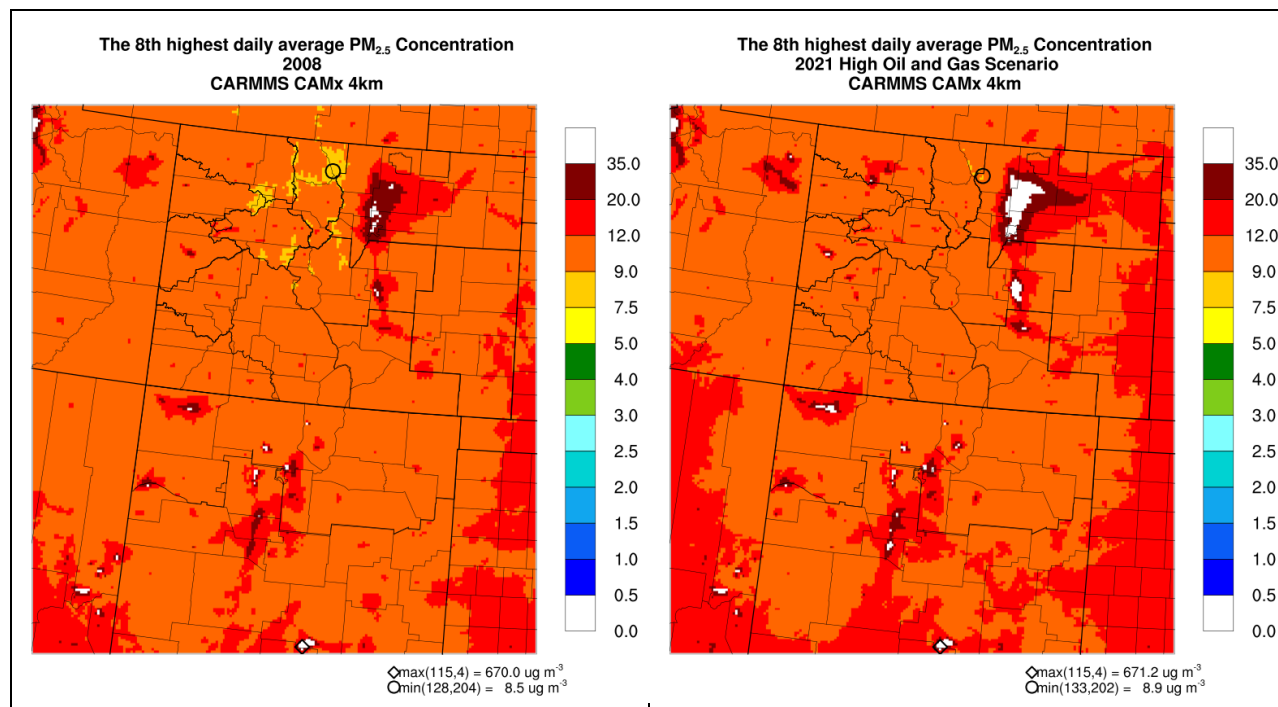
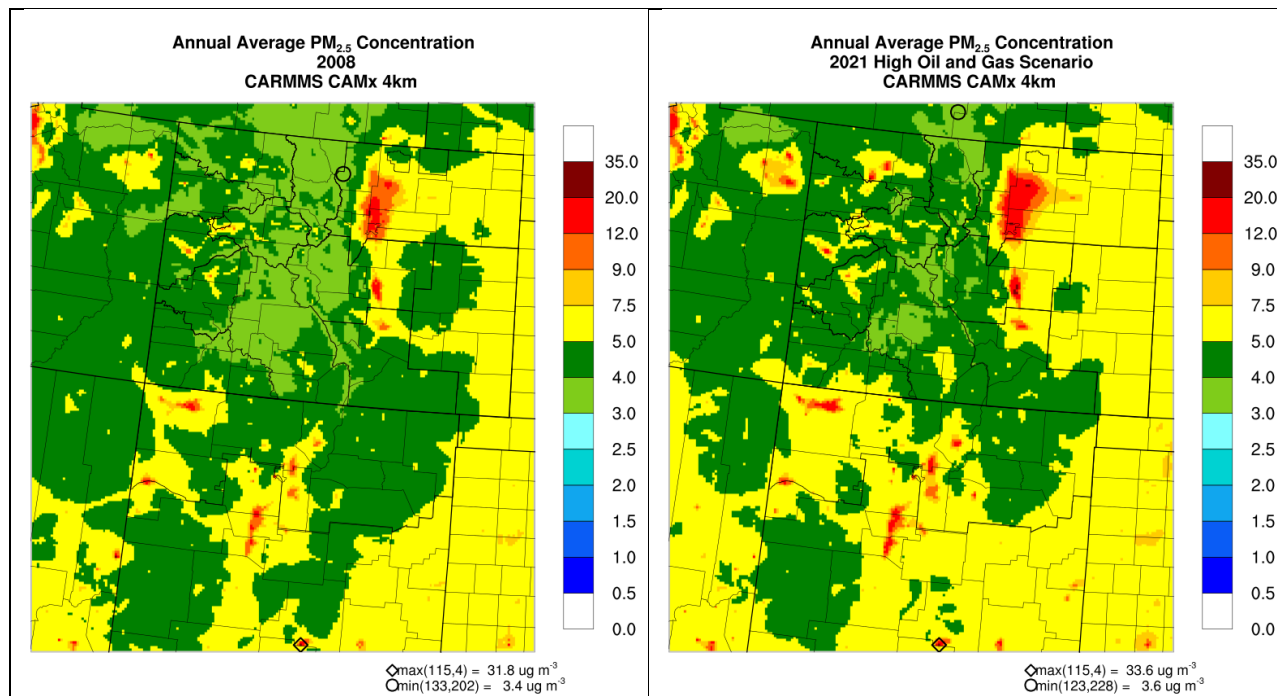


Figure 47 below shows the projected annual average PM_{2.5} concentrations for the 2008 base case and 2021 high development scenario. The highest annual average PM_{2.5} concentration is $\sim 30 \mu\text{g}/\text{m}^3$ in both the 2008 and 2021 scenarios and occurs in the southern most portion of the modeling domain near Ruidoso, New Mexico; this maximum value is and is due to wildfires. The plots indicate there are several areas where the modeled annual PM_{2.5} concentrations are projected to exceed the $12 \mu\text{g}/\text{m}^3$ annual ambient standard. Areas projected to exceed the standard areas are identified in red.

Figure 49 Annual Average PM_{2.5} Concentrations for the 2008 Base Case (left) and the 2021 High Development Scenario (right)



The maximum predicted contribution from PNG oil and gas sources to the 8th highest 24-hour PM_{2.5} and annual PM_{2.5} concentrations under the 2021 high scenario are 0.6 µg/m³ and 0.2 µg/m³, respectively.

Figure 48 shows the projected second highest daily average PM₁₀ concentrations across the modeling domain for the 2008 base case and the 2021 high development scenario. This figure also indicates projected exceedances of the standard, as indicated by the areas colored white on the maps, although there are fewer exceedances than for PM_{2.5}. The area of projected exceedances along the Front Range is projected to grow by 2021. Figure 49 shows the projected contribution of Pawnee NG oil and gas sources to PM₁₀ contributions by 2021. The maximum contribution shown is 3 µg/m³.

Figure 50 Second Highest 24-hour Average PM₁₀ Concentrations for the 2008 Base Case (top left) and 2021 High Development Scenario.

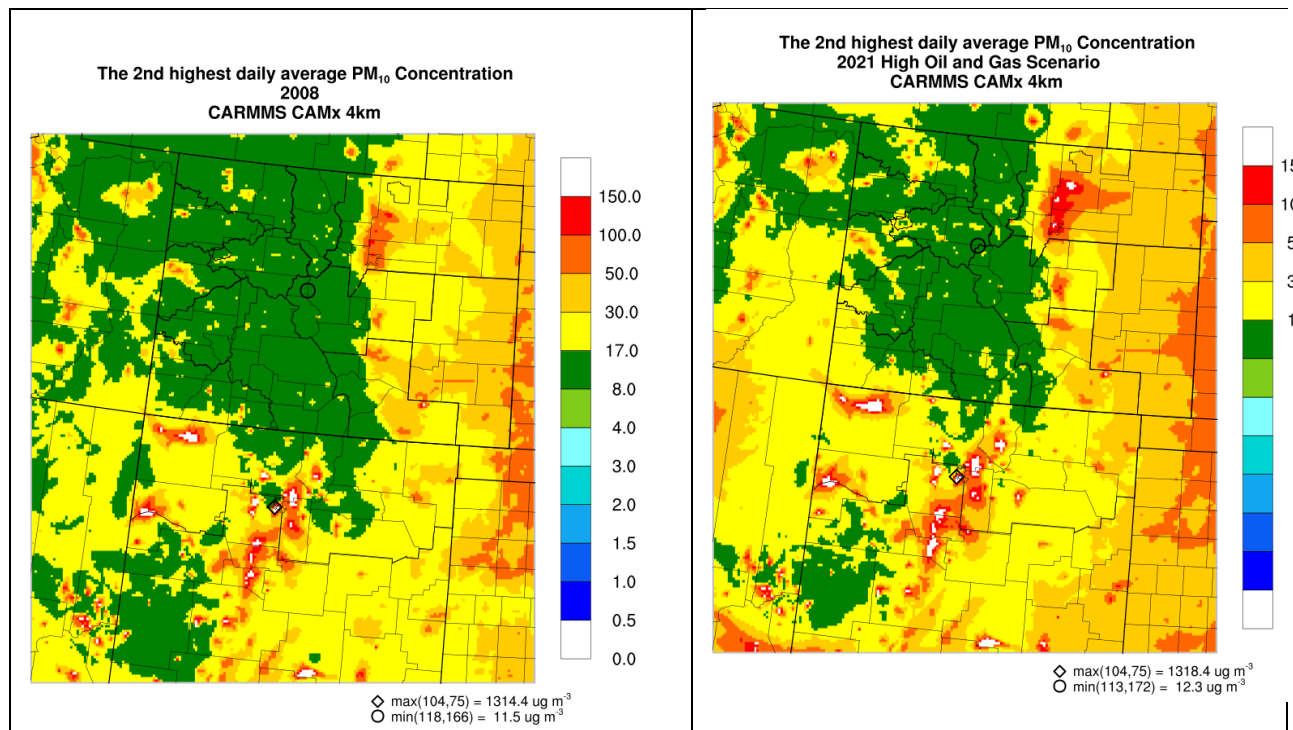


Figure 51 Contribution of PNG Oil and Gas Sources to 2nd-Highest 24-hour PM₁₀.

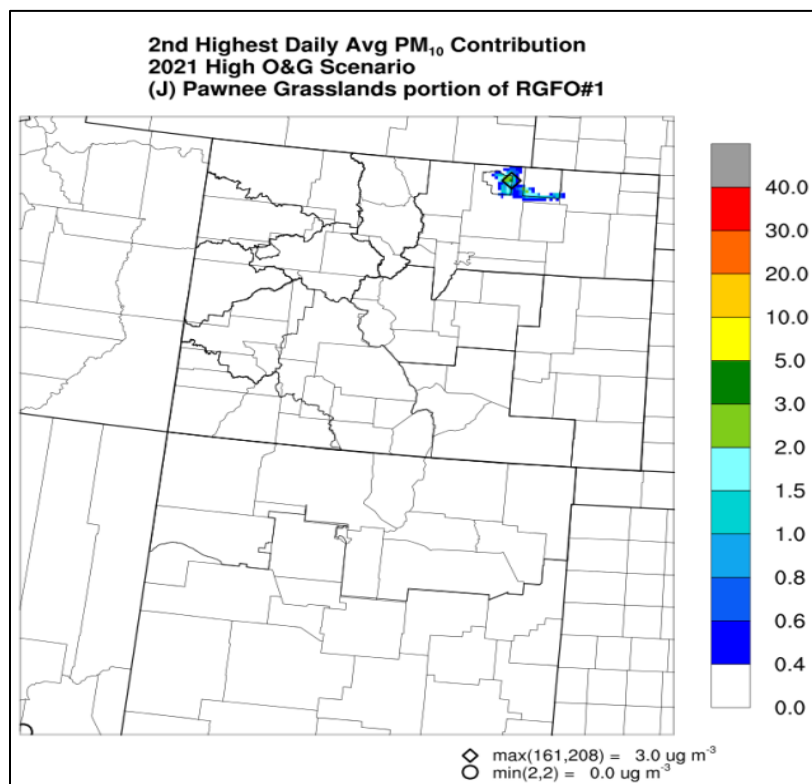
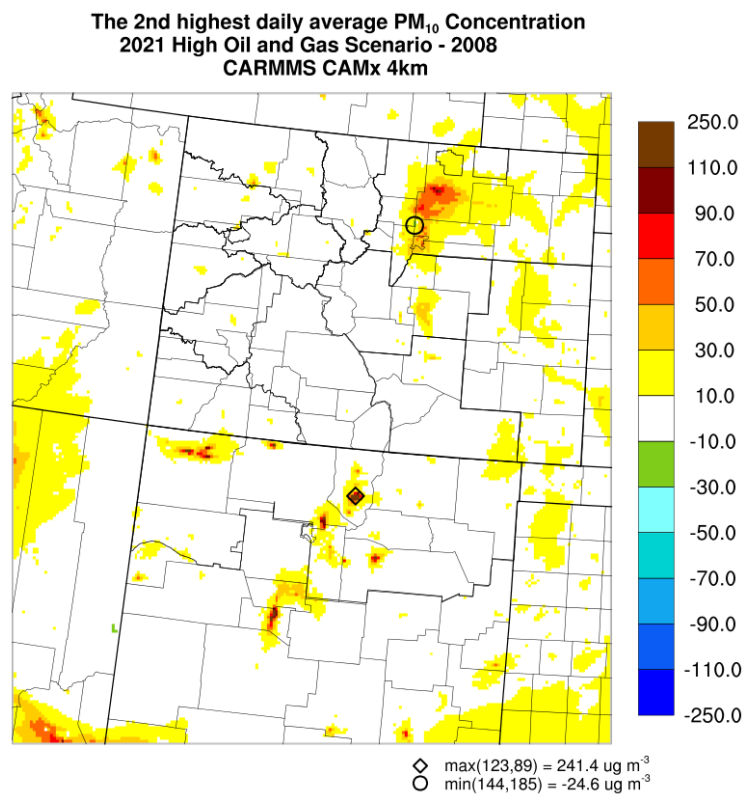


Figure 50 below shows the modeled change in the 2nd highest daily average PM₁₀ concentration from 2008 to 2021. The maximum projected change is 241.4 mg/m³ and occurs in north central New Mexico. Smaller increases in the 2nd highest daily average PM₁₀ concentration are projected to occur in the vicinity of the PNG.

Figure 52 Modeled change in the 2nd highest daily average PM10 concentration from 2008 to 2021



Cumulative Impacts to SO₂ and NO₂ concentrations

Figure 51 shows the projected impacts to SO₂ concentrations within the modeling domain for the 4th highest 1-hour daily maximum for the 2008 base case and 2021 high development scenario. The 2021 high scenario shows a maximum value 212 µg/m³, which exceeds the standard of 196 mg/m³, in Arizona. This exceedance occurred at a considerable distance from the Pawnee NG, and was not a result of impacts from projected Pawnee NG development. No exceedances are projected for the Pawnee NG area under the 2021 scenario.

Figure 53 Fourth highest (98th percentile) daily maximum 1-hour average SO₂ concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right).

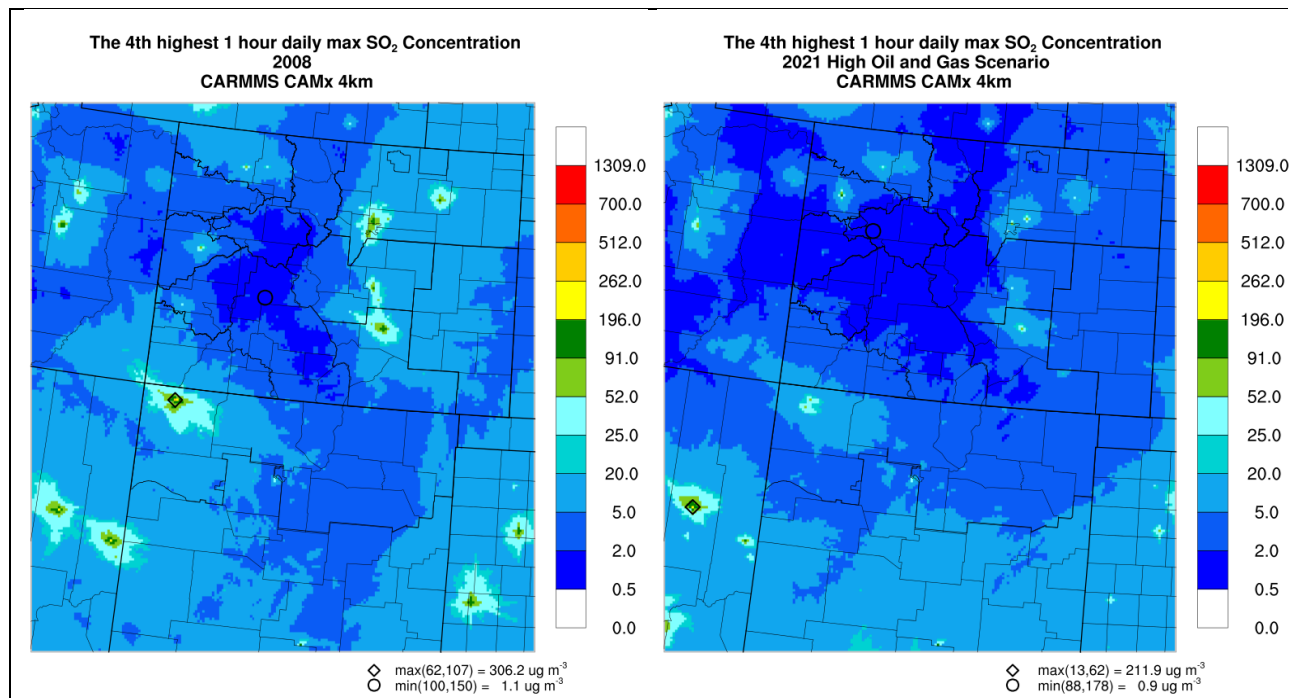


Figure 52 shows the predicted 2008 base case and 2021 for the second-highest 3-hour SO₂ concentrations across the modeling domain. The maximum predicted value for the 2021 high scenario is 185 $\mu\text{g}/\text{m}^3$, which is below the 3-hour standard of 1300 $\mu\text{g}/\text{m}^3$.

Figure 54 . Second highest 3-hour average SO₂ concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right).

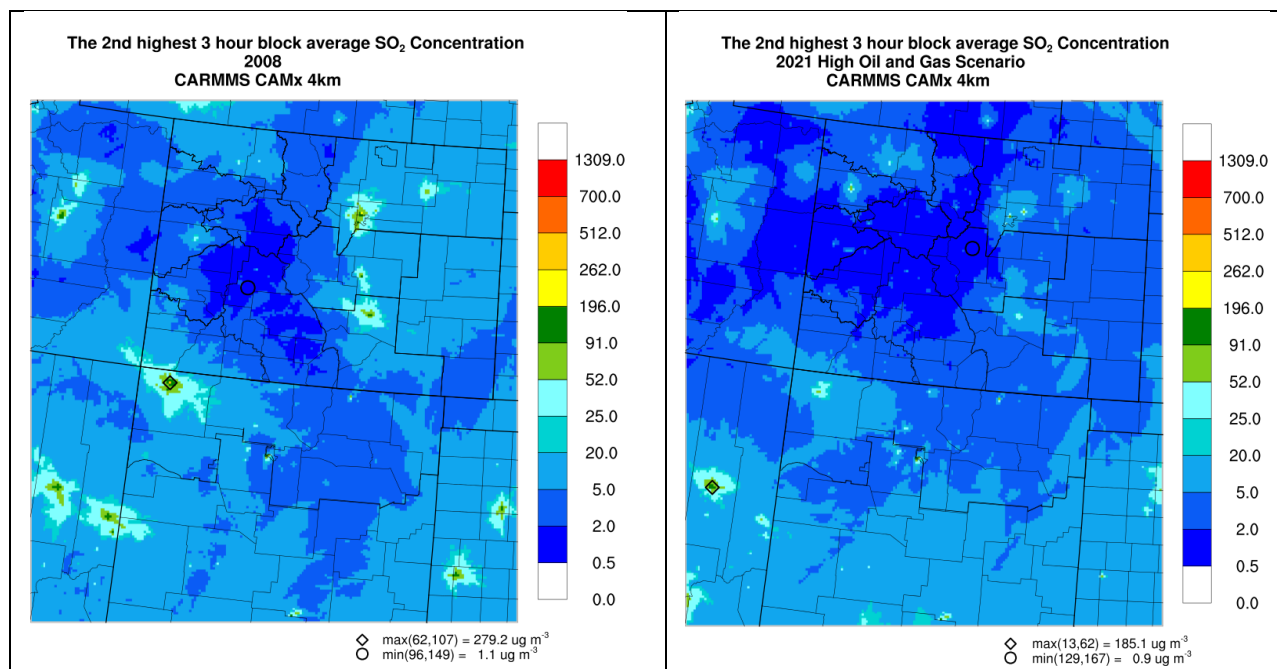


Figure 53 shows the modeled 2008 base case and 2021 annual average SO₂ concentrations across the modeling domain. The maximum modeled annual concentrations are 15.2 mg/m³ for the 2008 base case and 31.4 mg/m³ for 2021.

Figure 55 . Annual average SO₂ concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right)

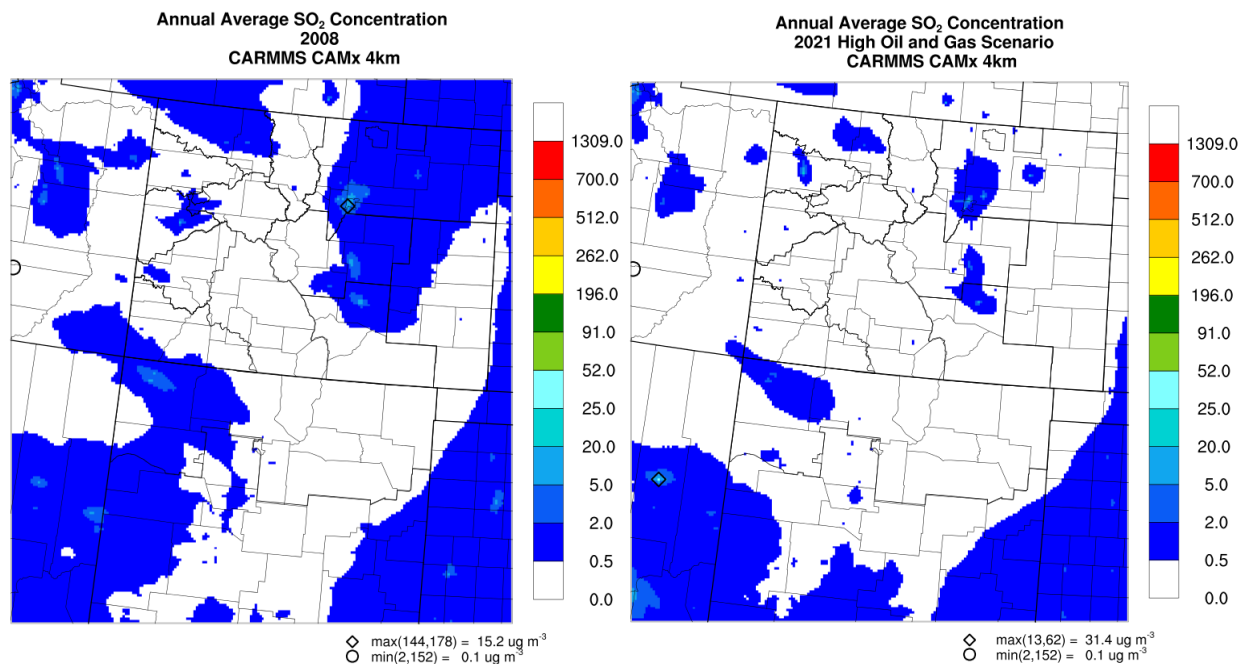
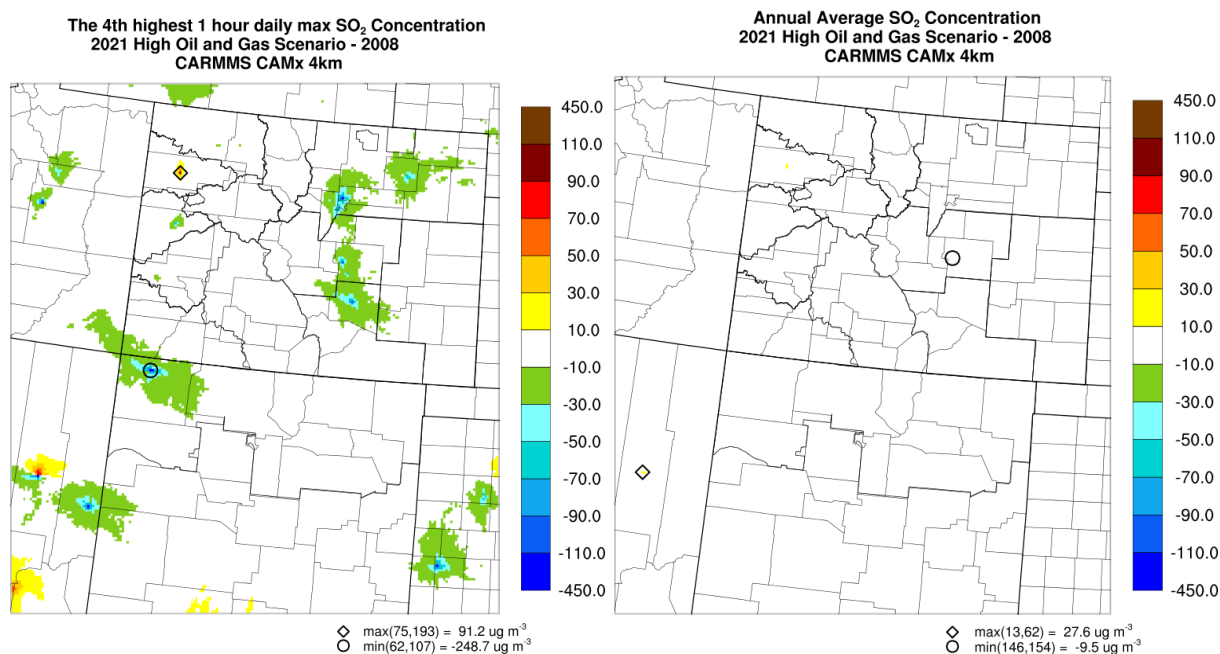


Figure 54 shows the relative change in the modeled 4th highest 1 hour daily maximum and annual average SO₂ concentrations from 2008 to 2021. The largest modeled increase in the 4th highest 1 hour daily maximum concentration, 91.2 µg/m³, is located in western Colorado. The figure shows the modeled 4th highest 1-hour daily maximum SO₂ concentrations in the vicinity of the PNG are projected to stay the same or decrease. The largest modeled increase in the annual average SO₂ concentration, 27.6 mg/m³, is located in Arizona. No change in annual average SO₂ concentration is projected in the vicinity of the PNG.

Figure 56 Modeled change in the 4th highest 1-hour daily maximum (left) and annual (right) SO₂ concentrations from 2008 to 2021



NO₂ NAAQS Analysis

Figure 55 shows the modeled cumulative impacts to NO₂ concentrations within the modeling domain for the 8th highest 1-hour daily maximum for the 2008 base case and 2021 high development scenario. The 2021 high scenario shows a maximum value of 514.8 $\mu\text{g}/\text{m}^3$, which exceeds the standard of 188 $\mu\text{g}/\text{m}^3$, located in New Mexico near the southern edge of the modeling domain.

Figure 57 Eighth highest daily maximum 1-hour average NO₂ concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right)

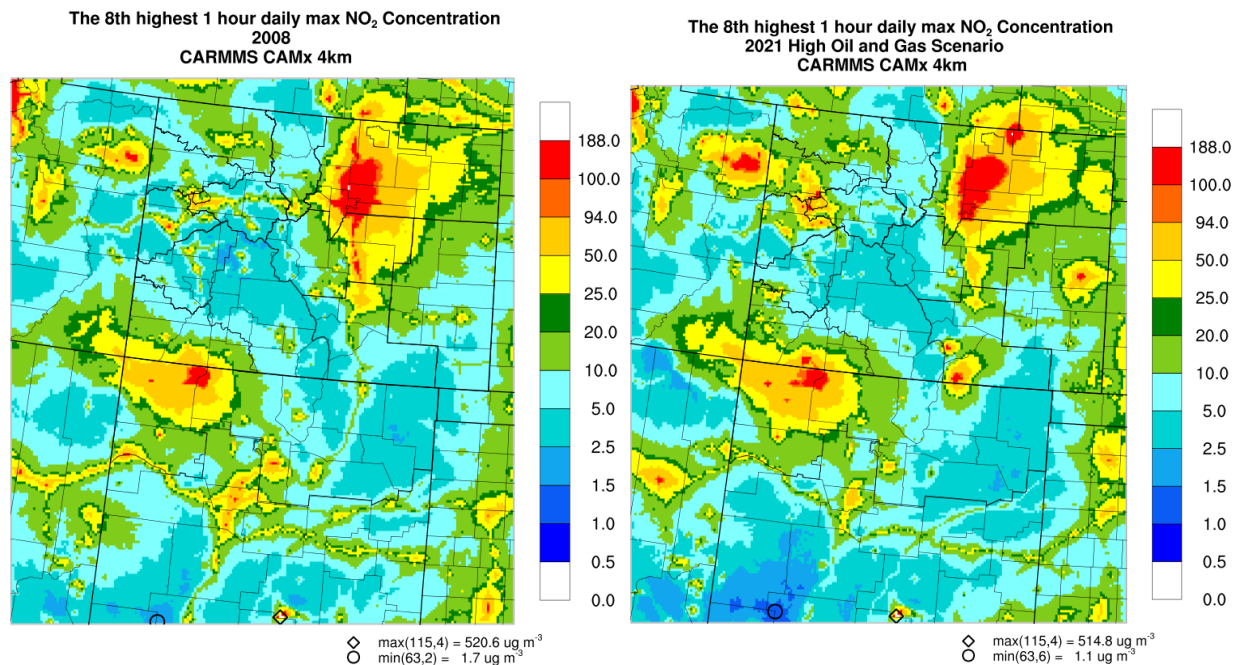


Figure 56 shows the modeled cumulative impacts to annual average NO₂ concentrations within the modeling domain for the 2008 base case and 2021 high development scenario. The 2021 high scenario shows a maximum value of 65.6 µg/m³, in the vicinity of the PNG. This is below the standard of 53 ppb (or 99 µg/m³).

Figure 58 Average Annual NO₂ Concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right)

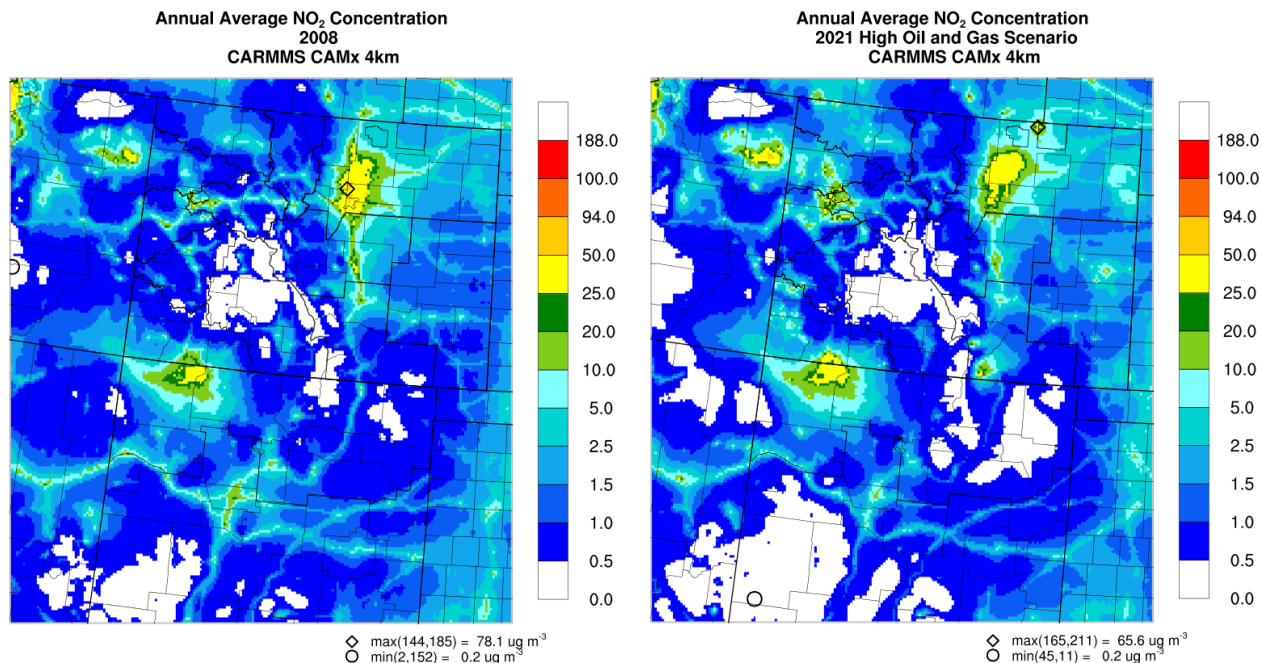


Figure 57 shows the relative change in the modeled 8th highest 1 hour daily maximum and annual average NO₂ concentrations from 2008 to 2021. The largest modeled increase in the 8th highest 1 hour daily maximum concentration is located in the vicinity of the PNG near the Wyoming border in northeast Colorado, at 217.1 mg/m³. The largest modeled increase in the annual average NO₂ concentration is located in approximately the same area, at 63.1 μg/m³.

Figure 59 Modeled change in the 8th highest 1-hour daily maximum (left) and annual NO₂ concentrations (right) from 2008 to 2021

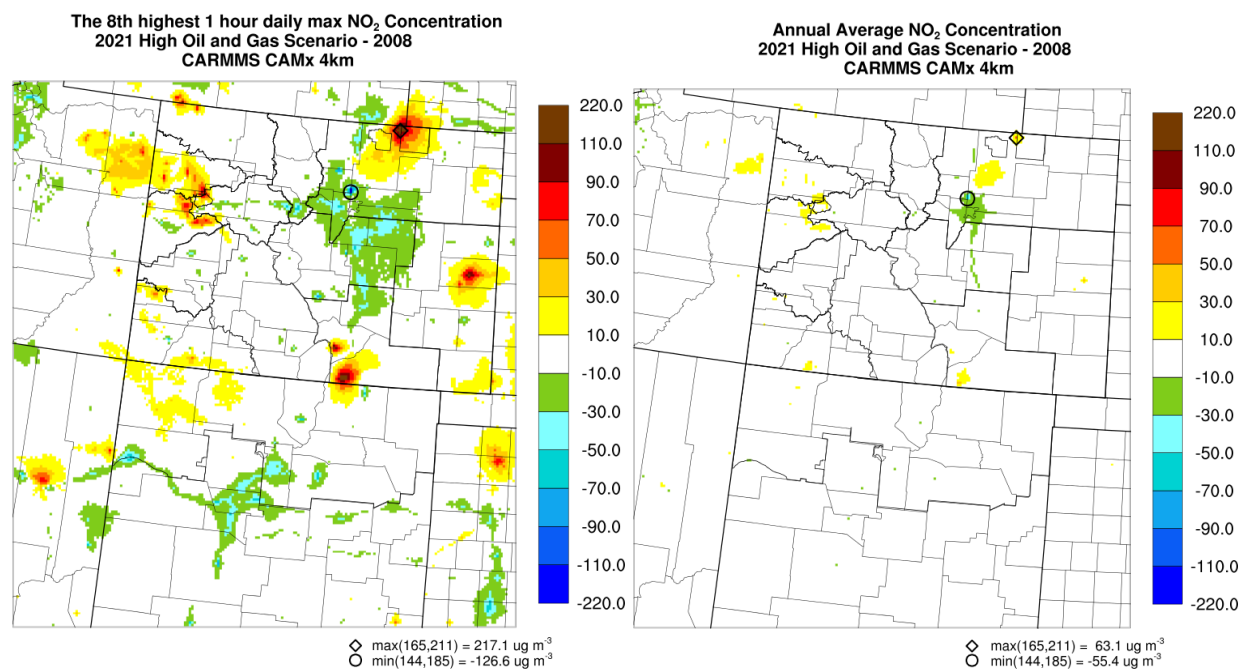


Figure 58 shows the modeled cumulative impacts to CO concentrations within the modeling domain for the 2nd highest 1-hour daily maximum for the 2008 base case and 2021 high development scenario. The 2021 high scenario shows a maximum value of 43,106 $\mu\text{g}/\text{m}^3$, which exceeds the standard of 40,082 mg/m^3 , located in New Mexico. Modeled CO values in the vicinity of the PNG are well below the standard.

Figure 60 Second Highest Daily Maximum 1-hour Average CO Concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right)

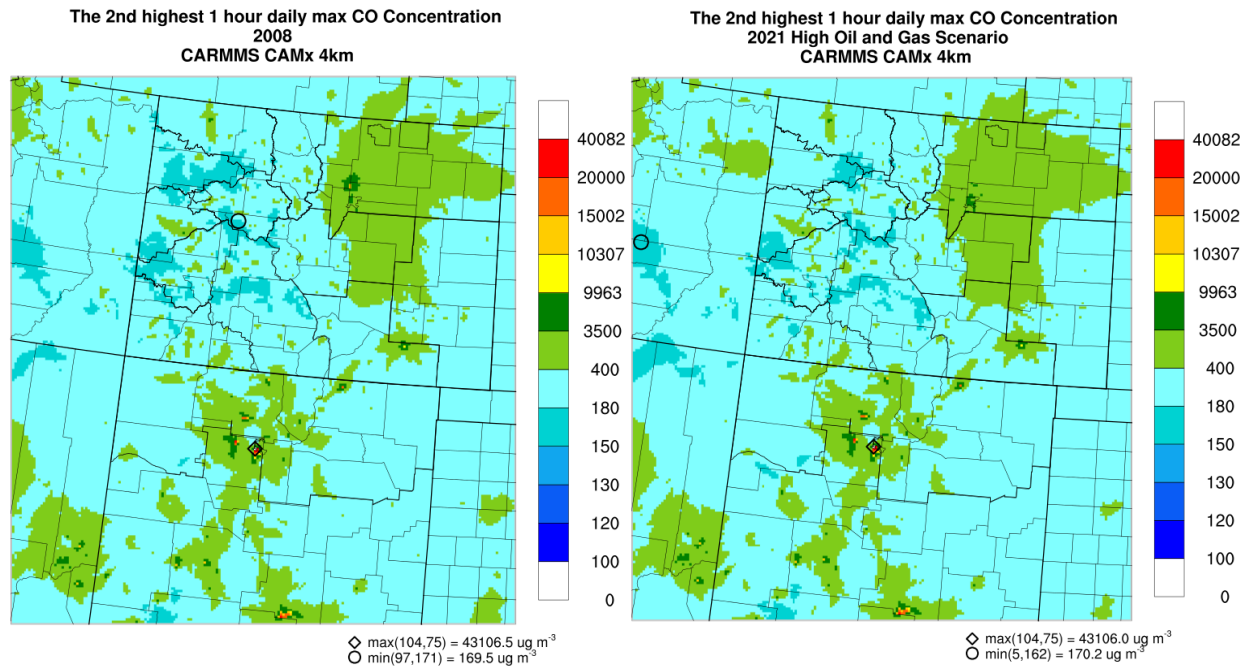


Figure 59 shows the modeled cumulative impacts to CO concentrations within the modeling domain for the 2nd highest 8-hour average for the 2008 base case and 2021 high development scenario. The 2021 high scenario shows a maximum value of 38,453 $\mu\text{g}/\text{m}^3$, which is above the standard of 10,305 $\mu\text{g}/\text{m}^3$, located in New Mexico. Modeled CO values in the vicinity of the PNG are below the standard.

Figure 61 Second Highest 8-hour Average CO Concentrations for the 2008 Base Case (left) and 2021 High Development Scenario (right)

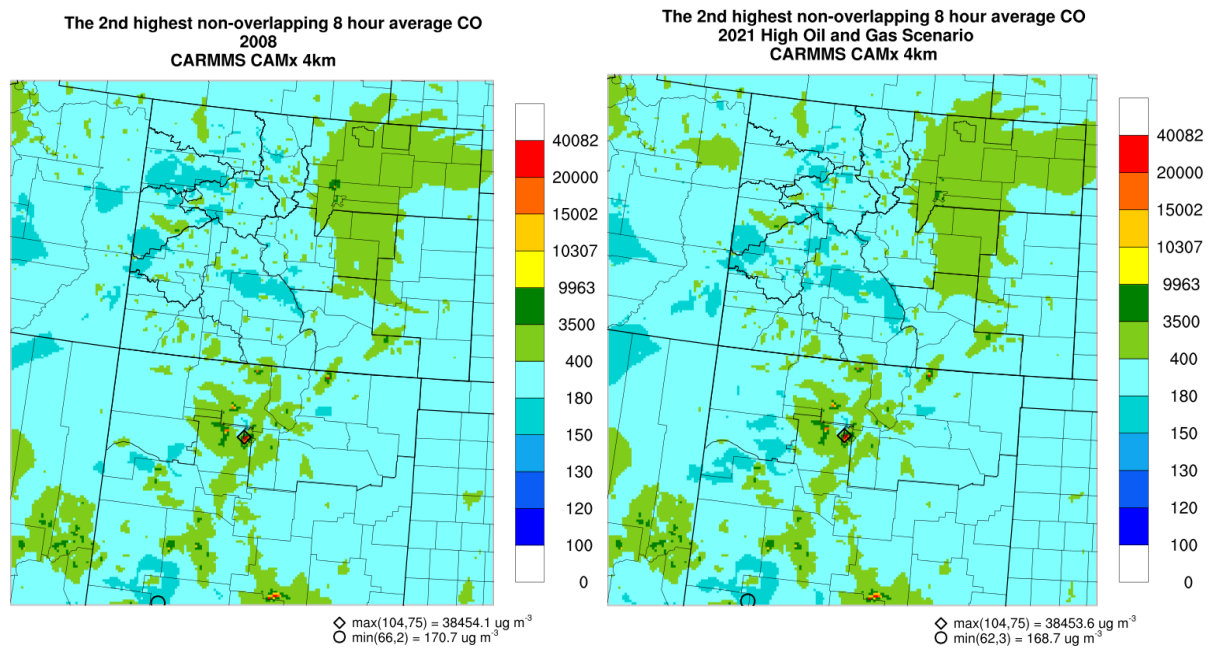
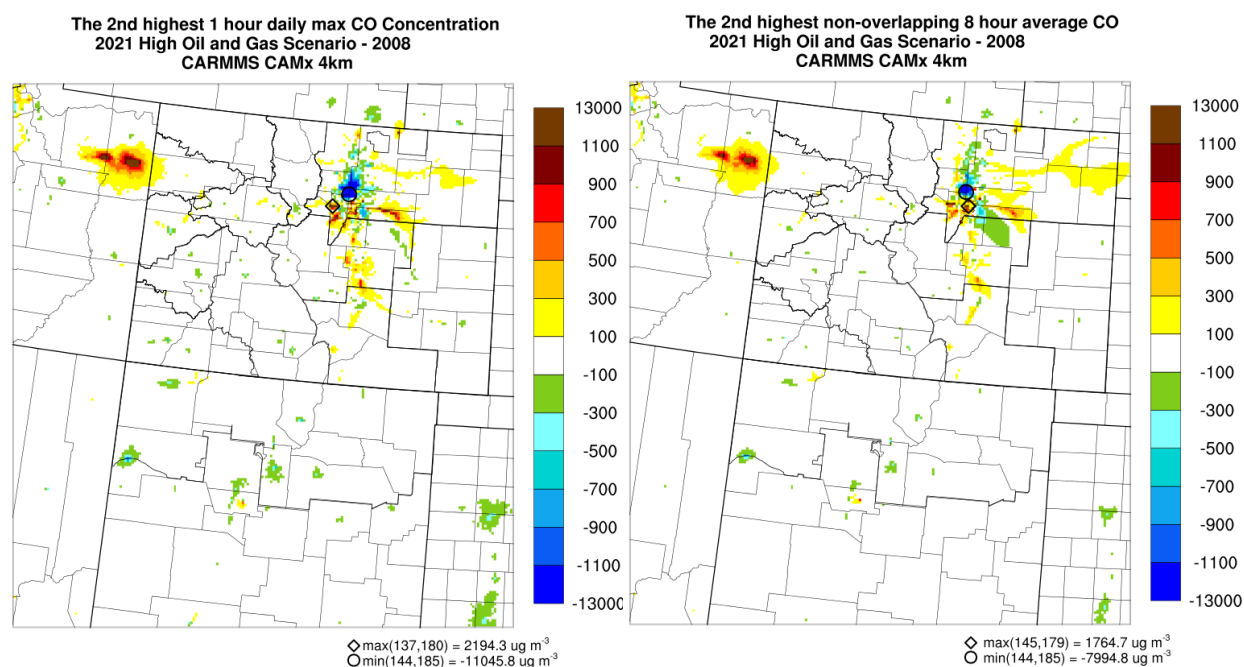


Figure 60 shows the relative changes in the modeled 2nd highest 1 hour daily maximum and 2nd highest 8 hour average CO concentrations from 2008 to 2021. The largest modeled increase in the 2nd highest 1 hour daily maximum CO concentration is located to the west of Denver, at 2,194 $\mu\text{g}/\text{m}^3$. The largest modeled increase in the 2nd highest 8 hour average CO concentration, 1,764.7 $\mu\text{g}/\text{m}^3$, is located over the city of Denver.

Figure 62 Modeled change in the 2nd highest 1-hour daily maximum (left) and 2nd highest 8-hour CO concentrations (right) from 2008 to 2021



Future Considerations

All federal actions that occur within an air quality nonattainment area must comply with the General Conformity Rule. This rule, established by the Environmental Protection Agency under the Clean Air Act, ensures that federal actions that occur within a nonattainment area do not interfere with the state's plan to meet air quality standards. As the southern portion of the Pawnee NG lies within the Denver metropolitan ozone nonattainment area, any oil and gas development resulting from a federal action that occurs within the nonattainment area will be required to meet the provisions of the general conformity rule. This determination will be required unless the activity causes only a small amount of emissions (below de minimis levels), is presumed to conform, or is otherwise exempt. If an action is not exempt and has the potential to emit ozone precursors (nitrogen oxides and volatile organic compounds) in excess of de minimis thresholds, the BLM will complete a general conformity determination as required by 40 CFR 93. For the Denver metropolitan nonattainment area, the de minimis levels are 100 tons of VOCs or 100 tons of NO_x . Because there are no development projects being considered under this analysis and thus no known emissions inventory is available to compare to the de minimis

levels, a conformity analysis for any specific development proposal will be completed by the BLM at the project level.

The proposed action being considered for this analysis is whether or not to make lands available for leasing. This action has been evaluated in accordance with the provisions of 40 CFR 93.153, which covers the applicability of conformity determinations. As stated in Subpart c, the conformity determination requirements do not apply to Federal actions that would result in no emissions increase or an increase in emissions that is clearly de minimis, or where the emissions are not reasonably foreseeable. 40 CFR 93.152 states that reasonably foreseeable emissions are “projected future direct and indirect emissions that are identified at the time the conformity determination is made; the location of such emissions is known and the emissions are quantifiable as described and documented by the Federal agency based on its own information and after reviewing any information presented to the Federal agency.”

The act of leasing or making lands available for lease does not authorize emissions generating activities. Leasing itself is similar in nature to the excepted activities listed in 40 CFR 93.153, “Transfers of ownership, interests, and titles in land, facilities, and real and personal properties, regardless of the form or method of the transfer.” Furthermore, the locations and amounts of indirect emissions that may result in the future if parcels are leased and developed cannot be determined at this time, and thus there are no reasonably foreseeable projected direct or indirect emissions. For these reasons, this action has been found to conform and does not require additional analysis under 40 CFR 93.

If parcels are leased and developed in the future, it is likely there would be project design features such as equipment sets, tanks, separators, compression engines, pump jacks, dehydration units, etc. that will require at least a minor new source review (i.e. permit) prior to construction. As stated in 40 CFR 93.153(d), “Notwithstanding the other requirements of this subpart, a conformity determination is not required for the following Federal actions (or portion thereof): - 40 CFR 93.153(d)(1) - The portion of an action that includes major or minor new or modified stationary sources that require a permit under the new source review (NSR) program (Section 110(a)(2)(c) and Section 173 of the Act) or the prevention of significant deterioration program (title I, part C of the Act).” While the specific details of any future project are not known at this time, emissions from any such permitted facilities would not be subject to the general conformity analysis provisions. In other words, equipment and operations that undergo state air permitting (minor or major) would already be analyzed for their potential impacts to ozone pollution and a conformity analysis is not required. This permitting exemption only covers stationary sources that are required to obtain a permit under the New Source Review or PSD programs; a source that is not subject to those permitting programs would not be covered by this exemption.

If parcels are leased and developed, the BLM will consider options for mitigating emissions to reduce impacts, if necessary, at the project level. The BLM recently developed a strategy to address air resource concerns within Colorado known as the Comprehensive Air Resources Protection Protocol (CARPP). This strategy document outlines potential mitigation measures that may be required of oil and gas operators to protect air resources.

As mentioned earlier, the CARMMS modeling study included an examination of impacts from potential oil and gas development of federal minerals throughout Colorado, both as regional source groups and cumulatively. The results from this study for many of these source groups are not available as of this writing but will be included in a BLM summary report in the next few months. In addition, future CARMMS modeling results will include two additional scenarios, one with a lower level of projected development, and an intermediate scenario that projects the same level of development as the high scenario presented here but includes additional controls that would lower emissions. Although the impacts presented here from Pawnee NG emissions alone are comparatively small, the BLM will consider cumulative impacts from oil and gas development within the state when considering mitigation for Pawnee NG oil and gas development. The BLM will also consider the results of the two additional CARMMS modeling runs when determining the appropriate level emissions controls.

The analysis presented here provides sufficient information for this level of decision, where the decision under consideration is whether or not to make lands available for leasing. As there is no way at this time to accurately project the exact location, nature, and extent of oil and gas development that might occur as a result of this decision, the air quality analysis considered a conservative but reasonable scenario based upon the RFD that included all wells within the boundary of the Pawnee NG. The number of wells analyzed was somewhat higher than the number of wells projected under any of the alternatives, and should therefore provide an upper bound to potential air quality impacts. As can be seen from the modeling results presented here, the potential impacts to air quality from potential Pawnee NG development alone are relatively small and will not cause or contribute to any violations of the NAAQS. While some exceedances are predicted to SO₂, particulate matter, and ozone standards, the individual contributions from the Pawnee NG to concentrations of these pollutants are extremely small. The contributions of Pawnee NG sources to AQRVs (i.e. visibility and deposition) presented here for Class I and sensitive Class II wilderness areas are also quite small.

Greenhouse Gases

Greenhouse gases are atmospheric gases that absorb energy radiated from the earth, preventing that energy from being lost to space. Greenhouse gases include water vapor, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and fluorinated gases. These gases help to regulate the temperature of the earth by preventing the loss of heat. Without these gases, the temperature of the earth would be much cooler than it is. Climate is influenced by natural changes that affect how much solar energy reaches Earth. These changes include changes within the sun, changes in Earth's orbit, and changes in the reflectivity of the Earth.

(<http://www.epa.gov/climatechange/science/causes.html>) Climate is also affected by natural variations in the amount of greenhouse gases present in the atmosphere. Greenhouse gases remain in the atmosphere for relatively long times. For example, the atmospheric lifetime of CO₂ in the atmosphere is estimated at 5 to 200 years, the lifetime of methane at 12 years, and the lifetime of N₂O is estimated to be 114 years (<http://www.ipcc.ch/ipccreports/tar/wg1/016.htm>).

Human activities have substantially increased the amount of greenhouse gases present in the atmosphere since the beginning of industrialization. The concentration of carbon dioxide, for example, has increased from 280 parts per million (ppm) prior to industrialization to around 400

ppm in 2013 (<http://www.esrl.noaa.gov/gmd/ccgg/trends/>)⁴⁴. This rise in CO₂ concentrations has been accompanied by increases in the global mean temperature. Globally the average annual temperature has risen since 1900 by about 1.5°F and is expected to rise another 2 to 10°F by 2100. The average annual temperature in the United States has risen by a comparable amount over the same time period but is expected to rise more than the global average over this century (Karl et al. 2009).

The extent of changes that have occurred to the climate is becoming more certain. The Intergovernmental Panel on Climate Change (IPCC) has concluded in its 2013 report that:

“Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased. Each of the last three decades has been successively warmer at the Earth’s surface than any preceding decade since 1850. In the Northern Hemisphere, 1983–2012 was *likely* the warmest 30-year period of the last 1400 years (*medium confidence*).”⁴⁵

Greenhouse gas emissions are often expressed in terms of carbon dioxide equivalents (CO₂e). This is a measure of the quantity of carbon dioxide that would be required to produce an equivalent amount of warming. For example, the CO₂e of carbon dioxide is 1, and for methane the CO₂e is approximately 21. This means that methane has approximately 21 times the warming potential of carbon dioxide.⁴⁶

In 2005 Colorado’s greenhouse emissions were 35 percent higher than they were in 1990. They are projected to grow 81 percent above the 1990 levels by 2020. Climate change related impacts observed in Colorado in recent decades include shorter and warmer winters with reduced snowpack and earlier spring runoff, more precipitation falling as rain rather than snow, and longer periods of drought (CDPHE 2010).

Energy-related activities in the United States account for three-quarters of human-generated GHG emissions. These activities account for 97 percent of carbon dioxide (CO₂), 37 percent of methane (CH₄) and 13 percent of nitrous oxide (N₂O) emissions in the country (EPA 2010a). Stationary sources such as power plants make up more than half of the energy-related emissions. Transportation’s contribution is one third of these emissions (CDPHE 2010).

The end use of natural gas is primarily as an energy source for the production of heat or electricity. Cleaner burning than coal, the contribution to greenhouse gases is primarily through emissions of carbon dioxide (CO₂). A 2009 inventory of fossil fuel sources in the United States shows that the contribution to greenhouse gases from natural gas combustion represents about a third of the total carbon equivalents from emissions from electrical and heat generation. Coal’s

⁴⁴ Dr. Pieter Tans, NOAA/ESRL (www.esrl.noaa.gov/gmd/ccgg/trends/) and Dr. Ralph Keeling, Scripps Institution of Oceanography (scrippsco2.ucsd.edu/).

⁴⁵ http://www.ipcc.ch/report/ar5/wg1/docs/WGIAR5_SPM_brochure_en.pdf

⁴⁶ <http://epa.gov/climatechange/ghgemissions/gases/ch4.html>

contribution is about 53 percent. Overall, natural gas combustion contributes to 17 percent of the greenhouse gas emissions in the United States (EPA 2011).

Natural gas is one of the top three major fuel sources that contribute to the United States' energy-related emissions of carbon dioxide (CO₂). Petroleum contributes about 42 percent of the total emissions, coal comes in second with approximately 37 percent, and natural gas contributes 21 percent (DOE 2009).

Aside from GHG emissions from fossil fuel consumption in the United States, the production, transmission, storage, and distribution of natural gas contributes to less than one percent of carbon dioxide (CO₂) emissions and about 17 percent of methane (CH₄) emissions. The source of most of these emissions is leakage from wells, pipelines, well-site treatment facilities, pneumatic devices, compressors, storage facilities, and other related systems. Emissions of carbon monoxide (CO), volatile organic compounds (VOCs), and nitrogen oxides (NO_x) are also emitted but in much smaller quantities (EPA 2010a).

The EPA has recognized the significance of equipment leaks and vented GHG emissions from both the natural gas and petroleum industries. A recent ruling by the EPA requires mandatory reporting of GHG from facilities that annually emit 25,000 metric tons or more of carbon dioxide (CO₂) equivalent (mtCO₂e) (EPA 2010b). In February 2014, the State of Colorado adopted new regulations that will affect emissions from the oil and gas industry. These include Regulation 7, which contains extensive requirements to control emissions of ozone precursors and hydrocarbons from equipment associated with oil and gas development and production.⁴⁷ In addition to extensive VOC reductions, the Regulation Number 7 revisions also regulate methane emissions from the oil and gas industry.⁴⁸ It also adopted Regulation 6, which incorporates the federal Standards of Performance for Crude Oil and Natural Gas Production, Transmission, and Distribution Standards contained in 40 CFR Part 60, Subpart OOOO.⁴⁹ These provisions should result in lower emissions of methane and other hydrocarbons from oil and gas operations.

Any subsequent development of leases for oil and gas production will lead to the emission of greenhouse gases, principally carbon dioxide (CO₂) and methane (CH₄). Table 57 gives estimated emissions of greenhouse gases that could result from Pawnee NG oil and gas development under the 2021 high development scenario. The annual greenhouse emissions estimates represent construction for all wells and one year of production emissions, under the assumption that all 354 wells would be operating at the same time; as this is unlikely to occur, the numbers are likely an overestimate of the maximum annual potential greenhouse gas emissions. Annual operating greenhouse emissions will be 85% of the total emissions shown for the maximum year.

⁴⁷ https://www.colorado.gov/pacific/sites/default/files/T1_AQCC_5-CCR-1001-9.pdf

⁴⁸ <http://www.colorado.gov/cs/Satellite?blobcol=urldata&blobheadname1=Content-Disposition&blobheadname2=Content-Type&blobheadvalue1=inline%3B+filename%3D%22Regulation+Numbers+3%2C+6+%26+7+-+Fact+Sheet.pdf%22&blobheadvalue2=application%2Fpdf&blobkey=id&blobtable=MungoBlobs&blobwhere=1251949265521&ssbinary=true>

⁴⁹ <http://www.gpo.gov/fdsys/pkg/FR-2012-08-16/pdf/2012-16806.pdf>

Table 57 Maximum Annual Potential Greenhouse Gas Emissions from Pawnee NG Development Under the 2021 High Development Scenario (tons)

CO ₂	CH ₄	N ₂ O	CO ₂ e	CO ₂ e (metric tons)
127,440	6,068	---	254,859	231,269

If all 354 projected wells were to be drilled in the first year and operate continuously for 25 years, the total GHG emissions would be approximately 4,950,000 metric tons in CO₂e for the new wells projected under all alternatives. Since it is highly unlikely that all 354 wells could be drilled in the first year and continue to operate at maximum production capacity for 25 years, this number is an overestimate of total potential greenhouse gas emissions.

The figures for CO₂ equivalence were computed using a global warming potential of 21 for methane. This is the figure used by EPA on its website. However, in a 2013 rulemaking EPA listed the GWP of methane as 25. If this figure is used instead of 21, the combined annual CO₂e listed in Table 57 increases to 279,129 tons CO₂e, or 253,293 metric tons. The 25-year total GHG emissions increases to approximately 5,500,000 metric tons, assuming all 354 wells would operate for all 25 years.

The numbers provided in Table 57 do not include greenhouse gas emissions that would result from processing the extracted oil and gas into final products or from the end use of those products. This is because it is not possible to determine what the volume or quality of extracted oil and gas will be or which types of products will ultimately be derived from the oil and gas. It is also not possible to forecast where, how, or when products extracted from the project area will be used. Oil, for example, can be used to produce many types of products, including diesel fuel, gasoline, aircraft fuel, kerosene, motor oils, plastics, solvents, lubricants, tires, asphalt, and a myriad of other possible end products. Natural gas could be used for electrical generation, home heating, home cooking, as a vehicle fuel, in fertilizer production (via the Haber–Bosch process), and for other uses.

For comparison, in 2010 the U.S. emissions of CO₂ (including some natural sources) amounted to roughly 6.3 billion tons, emissions of methane totaled approximately 734 million tons in CO₂ equivalents, and emissions of N₂O totaled roughly 337 million tons in CO₂ equivalents. Total U.S. emissions of greenhouse gases in CO₂ equivalents (including other greenhouse gases) was approximately 7.5 billion tons. When carbon sinks (i.e., losses of carbon from the atmosphere due to processes such as uptake by plants) are considered, net U.S. greenhouse gas emissions to the atmosphere were approximately 6.3 billion tons in CO₂ equivalents. During the same year, gross greenhouse gases emitted in Colorado totaled roughly 142 million tons in CO₂ equivalents, and net emissions (after subtracting carbon sinks) were roughly 113 million tons in CO₂ equivalents. (Center for Climate Strategies 2007). According to the EPA’s greenhouse gas equivalents calculator (<http://www.epa.gov/cleanenergy/energy-resources/calculator.html>), the greenhouse gas emissions shown in Table 57 in CO₂e are approximately equal to the annual greenhouse gas emissions from 48,688 passenger cars.

Emissions of greenhouse gases will contribute to climate change. The Intergovernmental Panel on Climate Change (IPCC) has concluded that “human influence on the climate system is

clear.”⁵⁰ However, it is not possible to predict the impact of potential Pawnee NG emissions on climate. Greenhouse gases are long-lived and therefore well distributed throughout the atmosphere. The impact of these gases to climate will also be distributed globally, but the degree of warming may not be equally distributed. In addition, the estimated quantity of greenhouse gases that could be emitted from development on the Pawnee NG is quite small relative to total U.S. and global greenhouse gas emissions, making it impossible to determine quantitatively the degree of change that might be attributable to these emissions. However, it is anticipated that the relative contribution of these emissions will be quite small.

There are estimates of potential impacts to climate resulting from the cumulative effects of greenhouse gas emissions. Climate projections specific to Colorado have been reported for the Colorado Water Conservation Board (Ray et al. 2008). These findings include the following projections:

- Colorado will warm by an average of 2.5 degree Fahrenheit by 2025 relative to the 1950-1999 baseline and by an average of 4 degrees Fahrenheit by 2050. Summers will warm more (by an average of +5 degrees Fahrenheit) than winters (by an average of +3 degrees Fahrenheit).
- The climate of the mountains will migrate upward in elevation. Winter projections indicate that Colorado will see less extreme cold months and more extreme warm months as well as more strings of consecutive warm winters.
- No consistent trends in precipitation were detected due to a high variability in modeling outputs.
- Snowpack is projected to decline in lower-elevations (below 8,200 feet) by the mid-21st century. During the same time period areas in Colorado above 8,200 feet are projected to see modest declines in snowpack.
- During the 21st century runoff will decline in most of Colorado’s river basins. Hydrologic studies indicate that the Upper Colorado River Basin may see average decreases of runoff ranging from 6% to 20% by 2050. One statistical stream flow model projects that decline at 45%.

Between 2000 and 2010 Colorado’s population grew by 16.9%

(www.indexmundi.com/facts/united-states/quick-facts/colorado/population-growth#map).

Projections of population growth estimate that the state will grow by 30% between 2020 and 2040 (DeGroen 2012). When considering that the implications of the climate change models suggests a reduction in total water supply by 2050, the growth in Colorado’s population could exacerbate efforts by water managers and planners who already face challenges in assuring water supplies to existing communities.

The impacts of climate change to Colorado’s water supply include a number of challenges. These include the following (Ray et al. 2008):

- Water demands by agriculture and outdoor watering may increase as rising temperatures raise the rates of evapotranspiration, lower soil moisture and alter the growing season.

⁵⁰ http://ipcc-wg2.gov/AR5/images/uploads/WG2AR5_SPM_FINAL.pdf

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- Reservoir operations such as flood control and storage may be affected by hydrologic changes in the timing and magnitude of snowmelt runoff.
 - The prior appropriation system and interstate water compacts may be further complicated by earlier runoff. This could affect when water rights holders receive water. Reservoir operation plans may have to be amended.
 - Warmer temperatures may place higher energy demands on hydropower plants. Cooling of power plants may be affected as lake and stream temperatures rise.
 - Increases in temperature and changes in soil moisture may result in a shift of mountain habitats toward higher elevations.
 - Forest health may respond to changes in air, water and soil temperatures. The relationships between forests, surface and ground water, insect pests and wildfire may be modified. For instance, water-stressed trees may be more vulnerable to insect outbreaks.
 - Increased stream temperatures may stress aquatic ecosystems leading to the spread of in-stream non-native species and diseases to higher elevations.
 - Changes in the timing and magnitude of stream flow may affect riparian ecosystems and increase the potential for non-native species to invade riparian areas.
 - Water and snow-based recreational pursuits may also be impacted. Changes in reservoir storage could affect lake and river recreation activities dependent on reservoir releases. Changes in stream flow timing and magnitude will impact rafting and fishing. Changes in the timing and character of snowpack will influence winter recreation activities. Tourism could be impacted.
 - With changes in long-term precipitation and/or soil moisture, ground water recharge rates may be affected. This could exacerbate an already challenging water supply issue as a growing population places increasing demands for water leading to greater pressures to develop groundwater resources.

3.11 Geology/Minerals

3.11.1 Fluid Minerals Existing Condition

The Pawnee National Grasslands (PNG) occupies the northern portion of the Denver Basin, which is an asymmetrical Laramide-age structural basin that is approximately oval in shape, stretched north to south, with a steeply dipping western flank and a gently dipping eastern flank. The greatest thickness of sedimentary rocks or axis of the Denver Basin lies parallel to the Front Range roughly on a line between Denver and Cheyenne, Wyoming. The axis plunges southward toward Denver, the deepest part of the Denver Basin. The sedimentary rocks of the Denver Basin range from Cambrian (Paleozoic) aged through undifferentiated alluvial deposits of Quaternary age. The sedimentary rocks rest on a Precambrian basement of metamorphic and igneous rocks that do not outcrop in the basin.

The fresh water bearing Upper Cretaceous Fox Hills Sandstone crops out along the western, southern, and eastern side of PNG. The southern and eastern Fox Hills outcrop follows the South Platt River from Greeley through Sterling. The western outcrop follows the course of US Route 85 northward. The Fox Hills is typically flat lying or dipping slightly westward under the PNG. The upper most Cretaceous-aged Laramie Formation and the Tertiary-aged White River Formations outcrop across the PNG. The thick Pierre Shale underlies the Fox Hills Sandstone but does not outcrop in the PNG. The oil prospective Cretaceous-aged Niobrara Formation lies below the Pierre Shale. Older Upper Cretaceous rocks below the Niobrara Formation separate it from the oil and gas prospective Muddy and Dakota sandstones of Lower Cretaceous age. These rocks are in turn underlain by Jurassic and Triassic aged rocks that separate them from the oil prospective Permian aged Lyons Sandstone. While many oil producing zones underlie the PNG, not all are currently productive or actively drilled there.

Mineral Resources

Federal mineral resources are categorized into three distinct groups (leasable, salable and Locatable) that are defined by various laws that provide for their management and disposition. The PNG are acquired lands that were once in private ownership. As a consequence locatable minerals are treated like leasable minerals. The geologic setting of the PNG creates favorable conditions for the occurrence of leasable (oil, gas and coal) and salable (sand, gravel, etc.) mineral resources. Otherwise locatable minerals (typically hydrothermal and placer deposits) are unlikely in the Pawnee Grasslands. However, stratiform uranium deposits do occur in the Upper Cretaceous Fox Hills Sandstone that lies above the hydrocarbon bearing rocks of the Niobrara Formation. The Niobrara is the current target of oil and gas development in the PNG.

Mineral Resources – Leasable

The category of traditionally Leasable Minerals (on federal lands) was established as a result of the Mineral Leasing Act of 1920. This act removed certain minerals from location under the Mining Law of 1872 and authorized the Secretary of Interior to issue leases for their extraction (currently applies to coal, phosphate, sodium, potassium, oil, oil shale, gilsonite, and natural gas). The act applies to National Forest lands reserved from the public domain, including lands received in exchange for timber or other public domain lands and lands with minerals reserved

under special authority. The Federal Onshore Oil and Gas Leasing Reform Act of 1987 (FOOGLRA) amended the Mineral Leasing Act of 1920 as described in Chapter 1, Relevant Laws, Regulations, and Guidance Documents.

Oil and gas are produced primarily from Cretaceous aged rocks across the Denver Basin; however some production occurs from older Paleozoic formations. The Denver Basin contains about 1,500 oil and (or) gas fields, concentrated along a northeast trend stretching from Denver into southwestern Nebraska. This trend is south of the PNG. These fields are “traditional” in that they commonly have a water contact below the hydrocarbon accumulation and a trapping mechanism that inhibits hydrocarbon migration in an otherwise permeable reservoir. They have limited lateral extent that is bounded by the trapping mechanism and the oil-water contact. They exclude reservoirs that exhibit unusually low pressure and permeability. Non-traditional reservoirs have low permeability and no down-dip water contact. They cannot be produced by traditional development practices that rely on sufficient reservoir permeability for oil flow without stimulation. Non-traditional reservoirs can be laterally extensive bounded only by the quality and quantity of the hydrocarbons present and the lithologic properties of the host rock. Current drilling in the PNG typically targets non-traditional oil reservoirs in the Niobrara Formation that are continuous in nature.

Development of Oil and Gas in the Pawnee National Grasslands

The current oil and gas interest in the PNG is principally in the Upper Cretaceous Niobrara Formation. Older, deeper oil and gas producing formations exist in the PNG, but interest in them is not presently significant. The Niobrara Formation is being exploited by non-traditional means while the older formations are traditional targets.

The Denver Basin, one of the largest sedimentary basins in the Rocky Mountain Region, was created during the Laramide Orogeny 60 to 80 million years ago. The basin is asymmetric with a gentle east flank and a faulted to very steeply dipping west flank. Source rock intervals for the Cretaceous include the Skull Creek, Mowry, Graneros, Carlile, Niobrara, and lower Pierre (Sharon Springs) shales. In the past, most production in the basin came from the Lower Cretaceous Muddy (D) and Muddy (J) sandstones. In the area of the Wattenberg Field south of the PNG production is found in the Dakota, J, D, Greenhorn, Codell, Niobrara, Hygiene, and Terry units. The Wattenberg area is a geothermal “hot spot” (Higley et al., 2003; Higley et al., 1992; Meyer and McGee, 1985). The principal reason for all the stacked pays in Wattenberg is the high temperature anomaly, which is inferred to be related to the Colorado Mineral Belt, which extends beneath the Denver Basin in the Wattenberg area (Higley et al., 2003). The high temperature anomaly along with the depth of burial of the source rocks converted the organic material contained in the source rocks to oil and gas. New discoveries in the Niobrara in the Denver Basin include Hereford Field northeast of Wattenberg, which is being developed with horizontal drilling and multi-stage hydraulic-fracture stimulations.

The PNG has a relatively low density of oil and gas development in comparison to existing wells within the Royal Gorge Planning area. As of January 2013, there are 62 wells located on approximately 43,000 leased acres of the PNG which are used for oil and gas production, water injection, and monitoring.

Niobrara Geology

The Niobrara Petroleum System consists of petroleum source beds and reservoir units within the Niobrara Formation, and it is also the source of hydrocarbons for reservoirs in the overlying Cretaceous Mesaverde sandstones (Terry and Hygiene). Thermogenic (thermally mature) oil and gas accumulations occur in the deeper part of the Denver Basin whereas biogenic gas accumulations occur on the shallow east flank of the basin. The Niobrara thermogenic production turns from gas to oil as the geothermal gradients decrease in all directions away from the Wattenberg “hotspot.” The area of thermally mature Niobrara source rocks is probably in the eastern half of the PNG. We assume that petroleum exploration will be successful in 50% of the PNG and that success will be largely in the eastern block.

The Niobrara Formation in the Denver Basin is a marine deposit consisting of interlayered shale, limestone and chalk beds with limited silt and sand layers. The Niobrara was formed in the Cretaceous seaway that extended across North America connecting the warm waters to the south with the cold waters of the north. Water circulation in the seaway brought warm southern water northward on the eastern side of the seaway and cold polar water southward along the western side. The water circulation pattern and the source of sediment to the west in what is now Utah caused thicker clay and sand deposition to the west and more limestone and chalk deposition to the east. Westward from the Denver Basin the Niobrara grades into the thick Mancos Shale in western Colorado. The Niobrara Formation of the PNG was more influenced by the warm southern waters and is characterized by limestone and chalk rather than clays, silts, and sands.

The Niobrara Formation of the PNG area is composed of the Fort Hayes Limestone Member at its base and the overlying interbedded Smokey Hill Member. The Smokey Hill Member has three limestone/chalk layers and intervening organic rich shale layers. The Smokey Hill Member is thicker than the Fort Hayes member and is important to the formation’s oil production. The shales of the Smokey Hill Member are the source rocks for the oil and the interbedded limestone and chinks are the reservoirs in which the oil is held. The target of horizontal drilling is always the most chalk-rich beds (R & R the Niobrara RMAG Ch1 Pg. 19). The organic material of the Niobrara Formation source rocks in at least the eastern half of the PNG is thermally mature because it was buried deep enough and exposed to an increase in heat associated the Wattenburg hotspot for a long enough time to generate oil.

Number of Wells per Pad

The RFDS estimates that 4 wells may be drilled on each pad north of Greater Wattenburg area, which includes the PNG (Page 21). Niobrara wells will most likely be drilled vertically to a depth of about 6000 feet and the laterals “kicked off” from that point. The laterals are horizontal extensions from the kick off point and extend up to 1.5 miles or more from that point.

According to the RFDS the number of wells that will be drilled on the USFS lands in the Pawnee area north of the non-attainment area is 126. These are expected to be horizontal wells drilled

from pad locations that may host 4 or more wells per pad. The RFDS indicates that the average number of wells per pad in the planning area is 3.2 wells and that about 67% of the new wells permitted (at the time of the RFDS preparation based on numbers from 2011). The RFDS says that in the area north of the Wattenberg AQNAA development will proceed (after initial stages of exploration) with pads averaging at least 3 wells per pad. In fact, the RFDS cites pads with as many as 16 wells and counts about 500 pads with from 4 to 8 wells per pad in the Greater Wattenberg AQNAA (pg 21).

Geometry of the PNG Acreage

The PNG is spread in two blocks separated by a north-south band of mostly private with some state lands that is one and a half townships (9 miles) wide in Weld County. The Niobrara Formation in the eastern block is currently undergoing the most intense development. The PNG land pattern in this block is more fragmented than in the western block. While the average size of discrete tracts of PNG mineral estate are approximately the same in both blocks, there are more and larger interspersed tracts of private lands in the eastern block.

Hydraulic Fracturing and Horizontal Drilling

Hydraulic fracturing (HF) is a well stimulation process used to maximize the extraction of underground resources – oil, natural gas and geothermal energy. The HF process includes the acquisition of water/mixing of chemicals, well perforating and production zone fracturing, and HF flow-back disposal.

Prior to the development of hydrocarbon bearing low permeability formations, domestic production of conventional resources had been declining. In response to this decline, the federal government in the 1970's through 1992, passed tax credits to encourage the development of unconventional resources. It was during this time that the HF process along with horizontal drilling was further advanced to include the high-pressure multi-stage fracking of long horizontal "laterals" drilled into tight or low permeability rocks.

The HF process involves the injection of a fracturing fluid and most often a proppant that is typically sand into the hydrocarbon bearing formation under sufficient pressure to further open existing fractures and/or create new fractures. This allows the hydrocarbons to more readily flow into the wellbore. HF coupled with horizontal drilling has gained interest recently as hydrocarbons previously trapped in low permeability tight sand and shale formations are now technically and economically recoverable. As a result, oil and gas production has increased significantly in the United States.

Horizontal wells reach far greater areas of an oil and gas reservoir than do vertical wells with far fewer surface acres disturbed. Multiple horizontal wells can be drilled from a single surface location or drilling pad. Horizontal wells are lateral extensions that can reach out from the surface location up to two miles or more. The typical horizontal well in the Niobrara Formation in the Greater Pawnee National Grasslands (PNG) starts as a vertical well drilled to a depth of about 6,000 feet. At that depth the well is deviated into the horizontal and extends outward to its total horizontal reach. Multiple wells are drilled from a single pad each with a horizontal

extension or lateral. The wells on a common pad are spud about 30 to 50 feet apart. The laterals from the individual wells on the same pad are drilled parallel to each other separated by a distance that maximizes hydraulic fracking efficiency. The laterals from each pad are typically drilled in opposed directions at 180 degrees separation. Laterals from half the wells on the pad may be drilled to the north and the other half to the south.

Generally, HF can be described as follows:

1. Water, proppant, and chemical additives are pumped at extremely high pressures down the wellbore.
2. The fracturing fluid is pumped through perforated sections of the wellbore and into the surrounding formation, creating fractures in the rock. The proppant holds the fractures open during production of the well.
3. Company personnel continuously monitor and gauge pressures, fluids and proppants, studying how the propping agent reacts when it hits the bottom of the wellbore, slowly increasing the density of proppant to water as the frack progresses.
4. This process may be repeated multiple times, in “stages” of a few hundred to a thousand feet or more along the entire length of a horizontal well bore that may be several thousand feet long. The wellbore is temporarily plugged between each stage to maintain the highest water pressure possible and get maximum fracturing results in the rock.
5. The plugs are drilled or removed from the wellbore and the well is tested for results.
6. The pressure is reduced and the fracturing fluids are returned up the wellbore for disposal or treatment and re-used, leaving the sand in place to prop open the fractures and allow the oil/gas to flow.

Operational Issues

Wells that undergo HF may be drilled vertically, horizontally, or directionally and the resultant fracture induced by HF can be vertical, or horizontal, or both. Wells in the PNG extend to depths of 6,000 to 7,000 feet, and horizontal sections of a well may extend up to 2 miles from the production pad on the surface.

The total volume of fracturing fluids is generally 95-99% water. In the Niobrara oil play, up to 5 million gallons may be used to fracture a horizontal well (much of which will be recovered for treatment, reuse and/or approved disposal).

Drilling muds, drilling fluids, water, and hydraulic fracturing fluids are stored in onsite tanks during the drilling and/or completion process. Equipment transport and setup can take several days, and the actual HF and flowback process can occur in a few days. For oil wells, the flowback fluid from the HF operations is treated in an oil-water separator before it is stored in a lined pit or tank located on the surface.

Gas emissions associated with the HF process are captured when the operator utilizes a green completion process. Where a green completion process is not utilized, gas associated with the well may be vented and/or flared until “saleable quality” product is obtained in accordance with Federal and state rules and regulations. The total volume of emissions from the equipment used

(trucks, engines) will vary based on the pressures needed to fracture the well, and the number of zones to be fractured. Emissions associated with a project, and HF if proposed, will be analyzed through a site specific NEPA document to ensure that the operation will not cause a violation under the Clean Air Act.

Beginning 1 January 2015, new source performance standards require green completion for new natural gas wells completions and natural gas wells re-completions. New wells in the DJ Basin may produce large quantities of natural gas, oil and condensate, and may be viewed by the BLM as natural gas wells at the permitting APD stage. Conditions of Approval (COA) may be applied to new Federal wells in the DJ Basin requiring green completion regardless of well type classification (gas or oil well) given the location of the new oil and gas development relative to the Ozone NAA. The O&G industries typically describe green completion as a routine process for oil and gas development in this area. However, the Niobrara Formation in the PNG area typically contains oil with very little, if any, gas and condensate produced.

High amounts of dust and combustion emissions typically accompany drilling, completion, and hydraulic fracturing related traffic. Multiple near-field particulate matter (PM) short-term (24-hour average) modeling analyses have been completed for development related traffic that show that high-levels of dust control are needed to achieve air quality compliance. The BLM routinely requires enhanced dust mitigation.

Emissions calculators used by the BLM are based on oil industry input. These calculators assume multiple engines totaling 10,000 – 15,000 horse power used for hydraulic fracturing. These engines usually only operate for short-durations, but could lead to short-term air quality concerns such as NO₂ 1-hour impacts. The BLM usually places a COA that all large development related engines are required to meet EPA Tier 2 or better Diesel Engine Standards.

Under either completion process, wastewaters from the HF process may be disposed in several ways. For example, the flowback water may be stored in tanks pending reuse; the water may be re-injected using a permitted injection well, or the water may be hauled to a licensed facility for treatment, disposal and/or reuse. Water containing certain air polluting compounds may require permitting.

Disposal of the waste stream following establishment of “sale-quality” product would be handled in accordance with Onshore Order #7 regulations and other state/federal rules and regulations.

Fracturing Fluids

As indicated above, the fluid used in the HF process is approximately 95% to 99% water and a small percentage of special-purpose chemical additives and proppant. There is a broad array of chemicals that can be used as additives in a fracture treatment – including, but not limited to, hydrochloric acid, anti-bacterial agents, corrosion inhibitors, gelling agents (polymers), surfactants, and scale inhibitors. The 1-5% of chemical additives translates to a minimum of 5,000 gallons of chemicals for every 1.5 million gallons of water used to fracture a well. Water used in the HF process is generally initially acquired from surface water or groundwater in the local area.

Potential Sources of Water for Hydraulic Fracturing

Freshwater-quality water is required to drill the surface-casing section of the wellbore per federal regulations; other sections of the wellbore (intermediate and/or production strings) would be drilled with appropriate quality makeup water as necessary. This is done to protect usable water zones from contamination, to prevent mixing of zones containing different water quality/use classifications, and to minimize total freshwater volumes. With detailed geologic well logging during drilling operations, the bottoms of these usable water zones are identified by the geologists/mud loggers on location, which aids in the proper setting of casing depths.

Below is a discussion of the sources of water that could potentially be used for hydraulic fracturing. The decision to use any specific source is dependent on BLM authorization at the APD stage and the ability to satisfy the water appropriation doctrine. From the operators' standpoint, their decision will be primarily driven by the economics associated with procuring a specific water source. In some cases water acquisition, use, and re-use may require permits from proper authorities. The operator will be responsible for all necessary permits and authorizations that are required by other federal, state and local authorities.

- (1) Irrigation water leased or purchased from a landowner.
The landowner may have rights to surface water, delivered by a ditch or canal that is used to irrigate land. The operator may choose to enter into an agreement with the landowner to purchase or lease a portion of that water. This is allowable, however, in nearly every case, the use of an irrigation water right is likely limited to irrigation uses and cannot be used for well drilling and HF operations. To allow its use for drilling and HF, the owner of the water right and the operator must apply to change the water right through a formal process.
- (2) Treated water or raw water leased or purchased from a water provider.
The operator may choose to enter into an agreement with a water provider to purchase or lease water from the water provider's system. Municipalities and other water providers may have a surplus of water in their system before it is treated (raw water) or after treatment that can be used for drilling and HF operations. Such an arrangement would be allowed only if the operator's use were compliant with the water provider's water rights.
- (3) Water treated at a waste water treatment plant leased or purchased from a water provider.
The operator may choose to enter into an agreement with a water provider to purchase or lease water that has been used by the public, and then treated as wastewater. Municipalities and other water providers discharge their treated waste water into the streams where it becomes part of the public resource, ready to be appropriated once again in the priority system. But for many municipalities a portion of the water that is discharged has the character of being "reusable." As a result, it is possible that after having been discharged to the stream, it could be diverted by the operator to be used for drilling and HF operations.
- (4) New diversion of surface water flowing in streams and rivers.
New diversion of surface waters are rare because the surface streams are already "over

appropriated,” that is, the flows do not reliably occur in such a magnitude that all of the vested water rights on those streams can be satisfied. Therefore, the only time that an operator may be able to divert water directly from a river is during periods of high flow and less demand. These periods do occur but not reliably or predictably.

(5) Reused or Recycled Drilling Water.

Water that is used for drilling of one well may be recovered and reused in the construction of subsequent wells. The BLM encourages reuse and recycling of both the water used in well drilling and the water produced in conjunction with oil or gas production. However, the operator must obtain the right to use the water for this purpose.

(6) On-Location Water Supply Wells.

Operators may apply for, and receive, permission from the state to drill and use a new water supply well. These wells are usually drilled on location to provide an on-demand supply. These industrial-type water supply wells are typically drilled deeper than nearby domestic and/or stock wells to minimize drawdown interference, and have large capacity pumps.

Potential Impacts to Usable Water Zones

Potential risks to surface and underground sources of usable waters may occur at various points in the oil and gas development process.

Impacts to or contamination of groundwater can come from point sources, such as chemical spills, damaged or leaking chemical storage tanks (aboveground and underground), industrial sites, landfills, household septic tanks, oil and gas well sites, and associated fluid pits, and mining activities. Groundwater contamination may occur through a variety of operational sources which may include, but are not limited to, pipeline and well casing failure, well (gas and water) drilling and construction of related facilities, and spills. Similarly, improper construction and management of open fluids pits and production facilities could degrade ground water quality through leakage and leaching.

Hydrocarbons or associated chemicals for oil and gas development, including HF fluids in excess of standards for minimum concentration levels, migrating into culinary water supply wells, springs, or usable water systems, could result in these water sources becoming non-potable. Water wells developed for oil and gas drilling could also result in a draw down in the quantity of water in nearby residential areas depending upon the geology; however it is not possible to predict whether or not any such water wells would be developed at this point in time.

Usable groundwater aquifers are most susceptible to pollution where the aquifers are shallow (within 100 feet of the surface depending on surface geology) or perched, are very permeable, or connected directly to a surface water system, such as through floodplains and/or alluvial valleys or where operations occur in geologies which are highly fractured and/or lack a sealing formation between the production zone and the usable water zones. If an impact were to occur, a greater number of people could be affected in densely populated areas.

Potential impacts on usable groundwater resources from fluid mineral extraction activities can

result from the three following scenarios:

- (1) Contamination of aquifers through the introduction of drilling and/or completion fluids through spills or drilling problems such as lost circulation zones.
- (2) Communication of the induced hydraulic fractures with existing fractures potentially allowing fluid migration into usable water zones/supplies. The potential for this impact is likely dependent on the existence and extent of natural fractures, the depth separating the target zone and the aquifer, rock type(s), and the local hydraulic gradients where those fluids are dissolved in the water column.
- (3) Cross-contamination of aquifers/formations that results when fluids from a deeper aquifer/formation migrate into a shallower aquifer/formation due to improperly cemented well casings.

The above impacts could occur as a result of the following processes:

Improper casing and cementing.

A well casing design that is not set at the proper depths or a cementing program that does not properly isolate necessary formations could allow oil, gas, or HF fluids to contaminate other aquifers/formations.

Natural fractures, faults, and abandoned wells.

If HF of oil and gas wells result in new fractures connecting with established natural fractures, faults, or improperly plugged dry or abandoned wells, a pathway for gas or contaminants to migrate underground could be created posing a risk to water quality.

Fracture growth.

A number of studies and publications report that the risk of induced fractures extending out of the target formation into an aquifer—allowing hydrocarbons or other fluids to contaminate the aquifer—may depend, in part, on the depth separating the targeted fractured formation and the aquifer. For example, according to a 2012 Bipartisan Policy Center report, the fracturing process itself is unlikely to directly affect freshwater aquifers because fracturing typically takes place at a depth of 6,000 to 7,000 feet, while drinking water aquifers are typically less than 1,000 feet deep. Fractures created during the HF process have not been shown to span the distance between the targeted formation and freshwater bearing zones.

Fracture growth and the potential for upward fluid migration, through coal and other geologic formations depend on site-specific factors such as the following:

- (1) Physical properties, types, thicknesses, and depths of the targeted formation as well as those of the surrounding geologic formations.
- (2) Presence of existing natural fracture systems and their orientation in the target formation and surrounding formations.
- (3) Amount and distribution of stress (i.e., in-situ stress), and the stress contrasts between the targeted formation and the surrounding formations.
- (4) Hydraulic fracture stimulation design including volume of fracturing fluid injected into the formation as well as the fluid injection rate and fluid viscosity.

Fluid leak off and recovery (flowback) of HF fluids.

Not all fracturing fluids injected into the formation during the HF process are recovered. It is theorized that fluid movement into smaller fractures or other geologic substructures can be sufficient that flowback efforts will not recover all the fluid. Also, the pressure reduction caused by pumping during subsequent production operations may not be sufficient to recover all the fluid that has entered the formation. It is noted that the loss of fluids due to movement into small fractures and pores is minimized by the use of cross-linked gels.

Willberg et al. (1998) conducted an analysis of HF flowback and described the effect of pumping rates on cleanup efficiency in initially dry, very low permeability (0.001 md) shale. Some wells in this study were pumped at low flowback rates (less than 3 barrels per minute (bbl/min)). Other wells were pumped more aggressively at greater than 3 bbl/min. Thirty-one percent of the injected HF fluids were recovered when low flowback rates were applied over a 5-day period. Forty-six percent of the fluids were recovered when aggressive flowback rates were applied in other wells over a 2-day period. In both cases, additional fluid recovery (10 percent to 13 percent) was achieved during the subsequent gas production phase, resulting in a total recovery rate of 41 percent to 59 percent of the initial volume of injected HF fluid. Ultimate recovery rate, however, is dependent on the permeability of the rocks, fracture configuration, and the surface area of the fracture(s).

The ability of HF chemicals to migrate in an undissolved or dissolved phase into a usable water zone is dependent upon the location of the sealing formation (if any), the geology of the sealing formation, hydraulic gradients and production pressures.

HF Fluids can remain in the subsurface unrecovered, due to “leak off” into connected fractures and the pores of rocks. Fracturing fluids injected into the primary hydraulically induced fracture can intersect and flow (leak off) into preexisting smaller natural fractures. Some of the fluids lost in this way may initially remain very close to the well bore after traveling minimal distances in the hydraulically induced fracture, before being diverted into other fractures and pores. Once “mixed” with the native water, local and regional vertical and horizontal gradients will dictate where and if these fluids will come in contact with usable water zones. Localized flow patterns may be altered slightly by the presence of faults, folds, joints, etc. as discussed below.

The following processes can influence effective recovery of the fracture fluids:

(1) Check-Valve Effect:

A check-valve effect occurs when natural and/ or newly created fractures open and HF fluid is forced into the fractures when fracturing pressures are high, but the fluids are subsequently prevented from flowing back towards the wellbore as the fractures close when the fracturing pressure is decreased (Warpinski et al., 1988; Palmer et al., 1991a). Also, a long fracture can be pinched-off at some distance from the wellbore. This reduces the effective fracture length. HF fluids trapped beyond the “pinch point” are unlikely to be recovered during flowback and oil/gas is unlikely to be recovered during the production phase.

In most cases, when the fracturing pressure is reduced, the fracture closes in response to natural subsurface compressive stresses. Because the primary purpose of hydraulic fracturing is to increase the effective permeability of the target formation and connect new or widened fractures to the wellbore, a closed fracture is of little use. Therefore, a component of the HF process is to “prop” the fracture open, so that the enhanced permeability from the pressure-induced fracturing persists even after fracturing pressure is terminated. To this end, operators use a system of fluids and “proppants” to create and preserve a high-permeability fracture-channel from the wellbore deep into the formation.

The check-valve effect takes place in locations beyond the zone where proppants have been emplaced (or in smaller secondary fractures that have not received any proppant). It is possible that some volume of stimulation fluid cannot be recovered due to its movement into zones that were not completely “propped” open.

(2) Adsorption and Chemical Reactions

Adsorption and chemical reactions can also prevent HF fluids from being recovered. Adsorption is the process by which fluid constituents adhere to a solid surface and are thereby unavailable to flow with groundwater. Adsorption to coal is likely; however, adsorption to other geologic material (e.g., shale, sandstone) is likely to be minimal. Another possible reaction affecting the recovery of fracturing fluid constituents is the neutralization of acids (in the fracturing fluids) by carbonates in the subsurface.

(3) Movement of Fluids Outside the Capture Zone

Fracturing fluids injected into the target zone flow into fractures under very high pressure. The hydraulic gradients driving fluid flow away from the wellbore during injection are much greater than the hydraulic gradients pulling fluid towards the wellbore during flowback and production (pumping) of the well. Some portion of the fracturing fluids could be forced along the hydraulically induced fracture to a point beyond the capture zone of the production well. The size of the capture zone will be affected by the regional groundwater gradients, as well as by the drawdown caused by producing the well. If fracturing fluids have been injected to a point outside of the wells capture zone, they will not be recovered during flowback or during production of the well. Site-specific geologic, hydrogeological, injection pressure and production pumping details should provide the information needed to estimate the dimension of the production well capture zone and the extent to which the fracturing fluids might disperse, and dilute.

(4) Incomplete Mixing of Fracturing Fluids with Water

Steidl (1993) documented the occurrence of a gelling agent that did not dissolve completely and actually formed clumps at 15 times the injected concentration in an induced fracture. Steidl also directly observed, in his mined-through studies, gel hanging in stringy clumps in many other induced fractures. As Willberg et al. (1997) noted, laboratory studies indicate that fingered flow of water past residual gel may impede fluid recovery. Therefore, some fracturing fluid gels appear not to flow with groundwater during production pumping and remain in the subsurface unrecovered. Such gels are unlikely to flow with groundwater during production, but may present a source of gel constituents to flowing groundwater during and after production.

Protective Measures:

The following measures are often taken to prevent impacts to surface and useable groundwater including drinking water:

Wells to be hydraulically fractured are typically set back away from all surface water and drinking water wells by some prescribed distance. This gives an added assurance that the fracking process will not impact surface water and drinking water wells.

Surface water and drinking water well water may be tested for indicator parameters both before and after the hydraulic fracturing procedure to determine initial water quality and water quality at some appropriate time after the fracking procedure. This provides a baseline water quality and may clearly indicate if these waters were impacted.

Monitoring wells may be required in some circumstances to determine water quality. These wells would be tested for indicator parameters both before and after the fracking procedure.

Old wells near hydraulic fracturing sites (within 1,500 feet in Colorado) must be identified and monitored. In many cases they must be evaluated for integrity and repaired or properly abandoned prior to the hydraulic fracturing activity. This prevents the high pressures of hydraulic fracturing from entering the old wells and potentially bridging the isolating formations between the target formation and shallower useable groundwater zones or flowing to the surface. It is possible that some of these old wells may be located on Federal No Surface Occupancy leases. The permitting process for the HF procedure will address the impacts of re-entering these old wells and prescribe suitable COAs to protect all resources. Typically re-entering old wells does not require the same level of surface disturbance as does drilling new wells. The equipment required to re-enter old wells is smaller than that required for drilling wells, access requirements are minimal (i.e. roads) and the time on location is much shorter than that for drilling.

All new oil and gas wells are cased below the deepest useable water zone and the casing is isolated from the useable water zones with cement. The wells are drilled to some prescribed depth below the useable water zone, steel casing is installed and centered from the surface to the bottom of the well, and cement is forced by pumping through a special “shoe” at the bottom of the casing until it returns to the surface in the annular space between the casing and the borehole wall. A cement bond log may be required to confirm that cement surrounds the casing throughout its length. Additional “strings” of casing may be run as needed to further protect the well and shallower formations. This procedure isolates all zones below the casing from the useable water zones behind the casing.

3.11.2 Fluid Minerals Environmental Consequences

Alternative 1-No Leasing

With regard to federal minerals, only existing leases can be developed under the existing lease terms in this alternative. The amount of federal unleased lands will climb if existing undeveloped leases expire and no new leases are issued. The federal oil and gas resource that is

not leased will be lost from production as these minerals are bypassed. This can already be seen as recently drilled horizontal wells or laterals terminate about 600 feet from the unleased federal mineral boundary. The federal mineral estate is typically fragmented and individual federal tracts are probably too small to justify future drilling by themselves. These small parcels do not contain sufficient hydrocarbon resources to justify stand-alone development costs. If they are bypassed, the oil and gas contained therein will in all likelihood be lost from production. Those laterals that terminate near boundaries abutting unleased lands cannot be extended into the unleased lands at some later date if those lands become leased. Some private oil and gas will also be lost from production because wells and the associated laterals are restricted from approaching closer than 600 feet to lease boundaries. Given the generally positive reception of oil and gas development in the local community the decision not to lease may not be supported by that population.

About 30% of the PNG is leased at this time (spring 2014). Therefore, only 30% of the oil contained within the PNG lands can be developed under the no leasing alternative. Approximately 178 million barrels of oil and 356 MCF of gas will be produced from federal minerals under the no leasing alternative. However, approximately 5 and a half billion barrels of oil in unleased federal minerals and 2 billion barrels of juxtaposed private and state oil will be bypassed assuming that 50% of the Greater PNG contains recoverable oil.

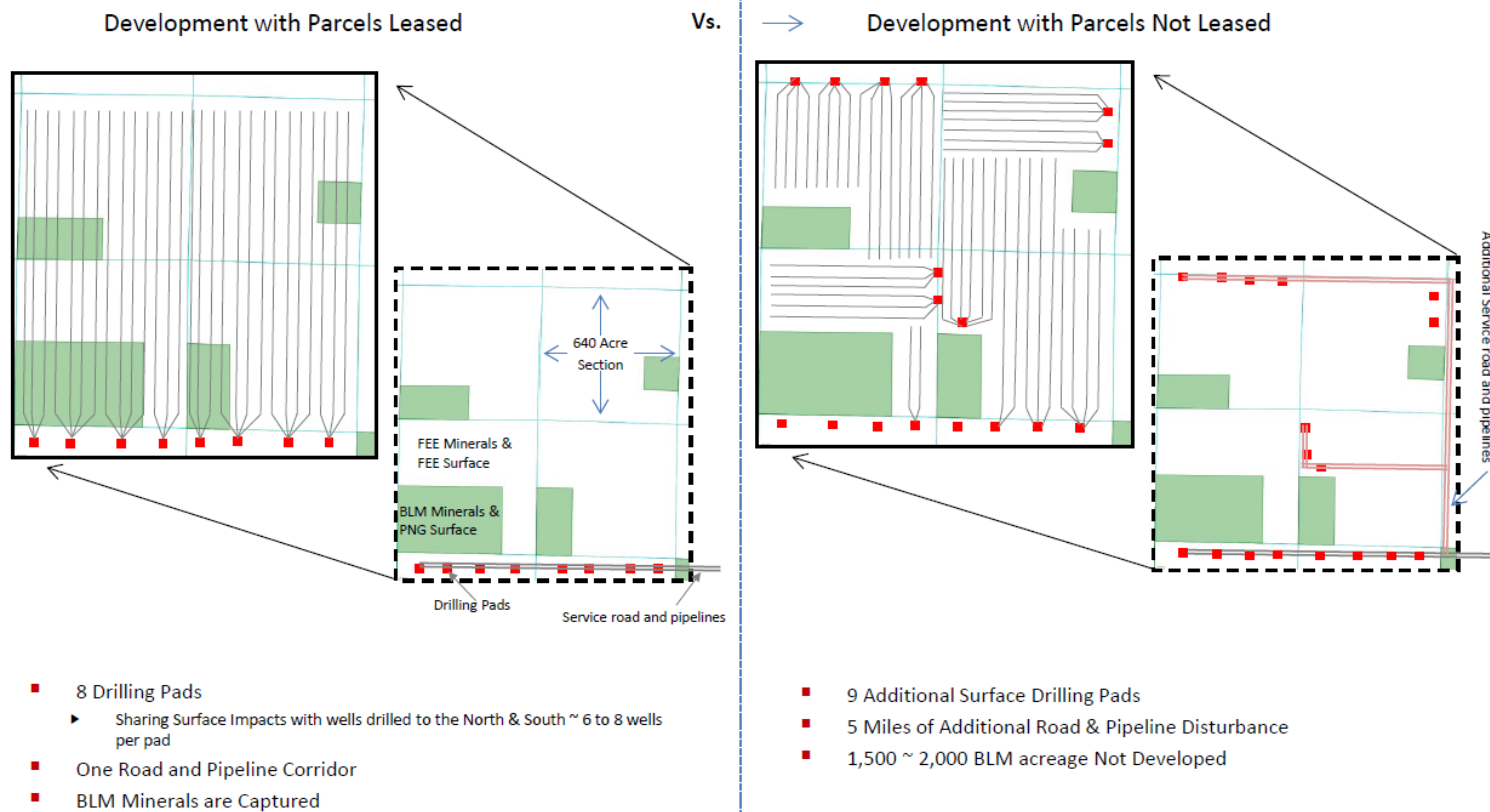
More land in the Greater PNG will be disturbed with the No Leasing Alternative than if all federal lands were leased. The federal lands are scattered in relatively small tracts across the Greater PNG. Unleased federal lands will not stop development of adjacent state and private lands because the state and private lands contain enough hydrocarbons to be economically viable, even if the intervening federal tracts are avoided. However, avoiding the federal tracts creates inefficiencies in the ideal drilling plan. The ideal drilling plan contains the fewest number of wells, pads, and associated roads and pipelines capable of developing all of the hydrocarbon resources. It assumes that all lands are available and that there are no obstructions to be avoided, such as unleased lands. Avoiding an obstruction and still developing hydrocarbons on both sides of the obstruction requires drilling wells on both sides of the obstruction rather than drilling horizontal wells through the obstruction from a single surface location. That means that more pads and more associated infrastructure will be needed to develop resources on all sides of unleased federal lands. In a typical case, significantly more, possibly even doubling of, pads and other infrastructure will be required to bypass unleased federal minerals than to fully develop all federal, state and private minerals (*see Figure 36*). It should also be noted that energy companies tend to avoid locating surface facilities particularly drilling pads on federal surface. While the ideal drilling plan assumes that all lands are available, drilling horizontal wells from multi-well pads allows energy companies to avoid locating facilities especially drilling pads on federal surface.

Even with the No Leasing Alternative we anticipate that the 40,000 acres currently under lease will be developed. They will not expire given the anticipated high success rate for drilling the Greater Wattenberg AQNAA, they will be drilled, and with a very high chance of success will be held by production. Leases that are held by production do not expire until they are no longer capable of production. .

Figure 63 Example of Parcel Development with and without Federal Minerals

Example of Parcel Development:

Scenario with and without BLM Minerals



Alternative 2-No Action

All unleased federal minerals that are available for leasing in the 1997 Forest Plan ROD (approximately 146,367 acres) may be leased and the oil and gas developed. Lease stipulations in the 1997 plan would be applied. They include no surface occupancy and timing restrictions. Assuming that the leases are issued in a timely manner when the industry is actively drilling in a particular area, no federal minerals will be bypassed and there will be no impact on the amount of petroleum products that will be produced. If, however, the leases are not timely issued, as is presently the case in some situations, some federal minerals may be bypassed and some additional surface disturbance may be encountered even on leased federal surface. Bypassing unleased minerals typically causes inefficiencies in ideal drilling development plans. Additional drilling locations are necessary to access minerals on both sides of unleased blocks that could have been accessed with fewer drilling locations. It is possible that some of the increased surface locations may fall on leased federal lands depending on the configuration of the leased versus unleased blocks. In that case more drilling locations on federal lands may result from unleased minerals. It is also assumed that some leased lands may be encumbered with no surface occupancy (NSO) and timing restrictions that will not restrict horizontal drilling from off-site locations under those NSO and timing restricted blocks.

Assuming that all unleased federal minerals will be leased and that all the federal minerals can be accessed by drilling locations either on the leased lands or from off-site locations with horizontal wells 100% of the federal minerals will be developed. In that case 590 million barrels of oil and 1180 MCF of gas will be produced from the federal leases. No federal minerals or juxtaposed state and private minerals will be lost from production.

Alternative 3-Leasing with No Surface Occupancy (NSO)

Few impacts are anticipated for development of the Niobrara Formation by horizontal wells with this alternative. Drilling of long laterals with multiple wells collocated on a common drilling pad greatly reduces the number of surface locations necessary for complete or nearly complete development of the subsurface resources. The industry has a long history of efficiently planning development and avoiding surface locations on federal lands. Given the scattered tracts of relatively small size of federal estate in the Greater PNG very few drilling pads would likely be planned for federal surface. In fact, the PNG administers only about 10% of the total mineral estate in the Greater PNG. A “straight-line” assumption would place 10% of the pads and wells on federal administered lands. However, it is very likely that federal locations will not be proposed at a rate at or above the straight-line assumption of 10%. Most surface locations will probably be proposed on non-federal surface. No leasing, not NSO, causes the most critical impact to hydrocarbon exploration, production, and surface disturbance.

NSO will impact wells that are drilled vertically to traditional targets. Traditional targets are limited in lateral extent and must be accessed by wells that are generally located vertically above the target. The current interest is in the non-traditional target of the Niobrara Formation. However, deeper targets have been productive in the Denver Basin and are ideally produced by vertical wells. In fact, these deeper targets would probably not be developed if they were thought to be small in size under the NSO alternative.

Production of oil and gas under this alternative is similar to the No Action Alternative. Assuming that all the federal minerals can be accessed by drilling from off-site locations with horizontal wells, 100% of the federal minerals will be developed. In that case, 590 million barrels of oil and 1180 MCF of gas will be produced from the federal leases. No federal minerals or juxtaposed state and private minerals will be lost from production.

3.12 Recreation

Introduction

No oil and gas development is being proposed in this analysis, only leasing options are being considered. This means that there will be no direct impacts to recreation since direct impacts refer to effects caused by an action which occurs at the same time and place. Since there is no immediate development being proposed in this study, the effects of well development will be indirect and cumulative since they will happen at a later date in the foreseeable future. Further environmental analysis at the site-specific level will need to be conducted when the locations of the wells are identified to determine direct effects from well development and construction.

For the reason that there is no oil and gas development proposed, the alternatives will use a Reasonable Foreseeable Development (RFD) scenario for analysis. The RFD was developed by the Bureau of Land Management and contains information on existing and projected wells.

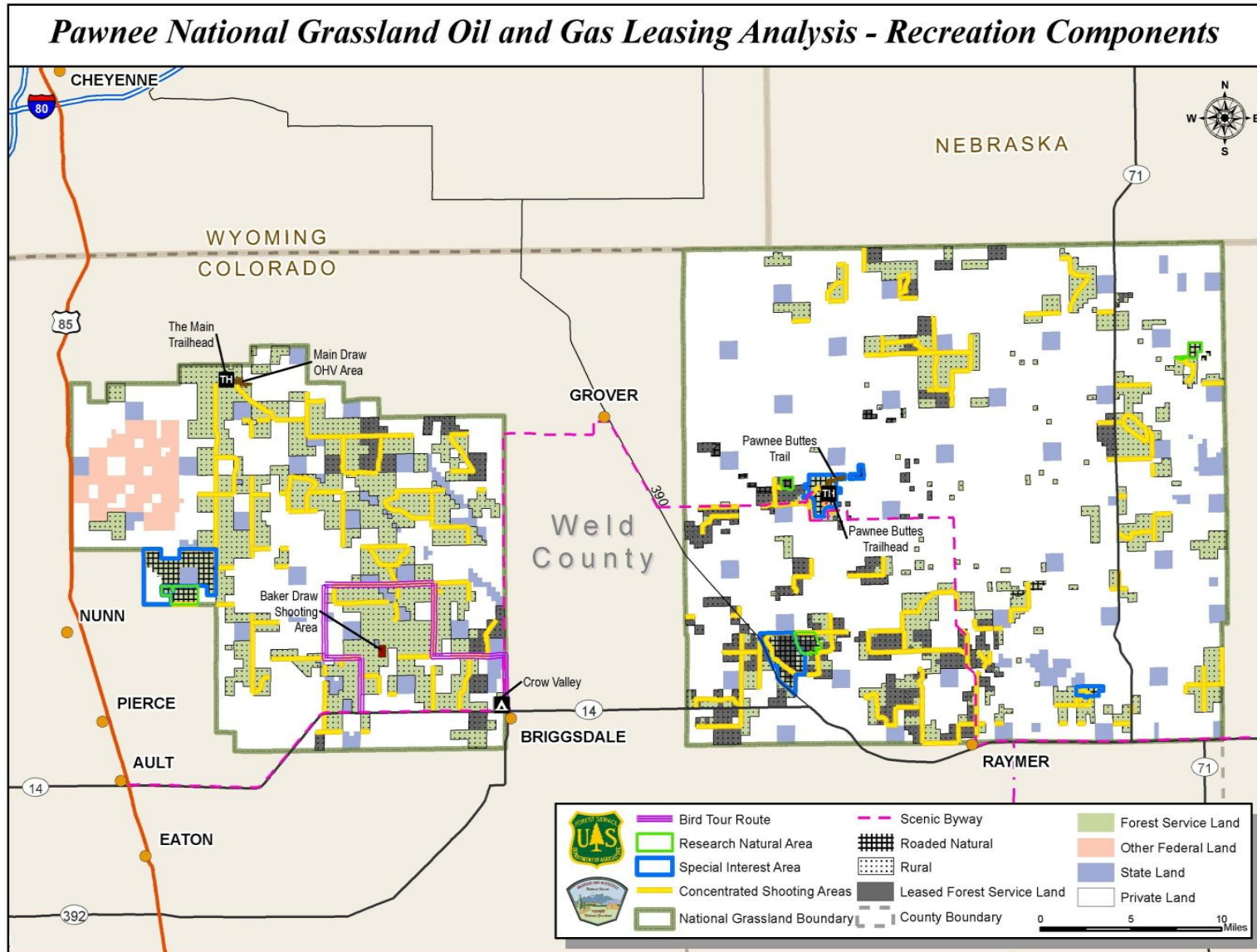
3.12.1 Affected Environment Recreation

There are seven key components for recreation that will be analyzed per alternative. These are:

- (1) Research Natural Areas (RNA): There are three proposed RNAs within the analysis area. These are the Indian Caves Proposed RNA (approx. 385 acres), the little Owl Creek Proposed RNA (approx. 1,105 acres), and the Keota Proposed RNA (approx. 825 acres). (Approximately 2,315 total acres of RNAs)
- (2) Special Interest areas (SIA): There are two on the Pawnee National Grasslands. The Prairie Ecosystem Demonstrations areas SIA and the Pawnee Buttes SIA. . (Approximately 11,460 total acres of SIAs)
- (3) The Recreation Opportunity Spectrum (ROS): Two classifications are found in the project area. These are Roaded Natural (approx. 13,335 acres) and Rural (approx. 179,440 acres)
- (4) Developed Recreation: Two developed sites exist within the analysis area: Crow Valley Recreation Area (approx. 16 acres) and the Pawnee Buttes Trailhead (approximately .3 acres)

- (5) Dispersed Recreation: Several dispersed activities occur on the Pawnee National Grassland. For the purpose of this study, the dispersed activities will include: motorized recreation (Main Draw OHV Area and Trailhead approx. 175 acres), bird watching, hiking (approx. 1.5 designated miles), and recreational target shooting (Baker Draw Designated Shooting Area approx. 130 acres)
- (6) Recreation Special Uses: The Pawnee National Grasslands administers seven special use permits to outfitter and guides for bird tours and a recreation event.
- (7) Scenic Byways: The Pawnee Pioneer Trails Scenic Byway is the only scenic byway that transverses the Pawnee National Grassland. (Approx. 128 miles)

Figure 64 Recreation Components on the PNG



3.12.2 Recreation Environmental Consequences

Research Natural Areas (RNA) and Special Interest areas (SIA)

No Action Alternative Indirect Effects for Both Short and Long Term:

While the RNAs within the Pawnee Nation Grassland are proposed RNAs, they still fall under the 2.2 Research Natural Areas management area direction in the 1997 Forest Plan revision. This means that they are to be managed as RNAs. Under the Forest Plan direction, RNAs and SIAs, with the exception of the Pawnee Buttes SIA, are managed under the No Surface Occupancy (NSO) stipulation. The purpose of this stipulation is to protect the values for which the areas were designated. There would be no negative indirect effects, either short or long term, of the No Action alternative because these areas would remain under the NSO stipulation. As such, there will be no construction activities or well pads established within these specially designated areas. The values for which these areas were designated will continue to be protected and there would be no change to the resource caused by this alternative.

The Pawnee Buttes SIA is identified as No Lease in the 1997 Forest Plan decision. Similar to the NSO stipulation, there would be no surface disruption within the Pawnee Buttes SIA. Consequently, there would be no negative indirect impacts either short or long term as a result of this alternative on the Pawnee Buttes SIA .

It is a positive that this alternative continues to protect the recreation component. The intensity scale would rate as negligible however because there would be no change to these recreation components from the No Action alternative.

No Action Alternative Cumulative Effects:

Although there would no negative indirect effects from this alternative, there would be cumulative impacts. These impacts would result from the development of lands already leased within the vicinity, or from the future leasing and development of surrounding non-forest lands. If these lands were to be developed, the sense of place the RNAs and SIAs offer would be permanently altered. The open natural spaces these areas possess would appear encroached upon as the boundaries of the RNAs and SIAs are not readily apparent on the ground. The scenic values of these areas would be compromised as well pads pepper the landscape and break up view sheds around these areas, and the feeling of being out in nature would be compromised by the presence of engineered oil and gas development within in the vicinity of these undeveloped lands.

In terms of recreation values, the Pawnee Buttes is the most popular of these areas on the Grasslands. This is a destination place with unique characteristics that cannot be found elsewhere with the main attraction being the Pawnee Buttes. Some popular activities in this area include hiking, equestrian use, and wildlife watching. This alternative will actually serve to intensify the described cumulative impacts to this particular SIA because the impacts are affecting a finite destination resource that is irreplaceable considering the

opportunities sought there and the fact that it is the only place the Buttes exist within the Grasslands.

Under the Impact Intensity scale, the cumulative impacts would rate as Moderate Adverse as the resources would be negatively impacted, but it would not be detrimental to the RNAs and SIAs as some protections from the NSO stipulation would remain in place. This rating would remain in effect until the well pads were removed and reclaimed.

The Recreation Opportunity Spectrum (ROS):

No Action Alternative Roaded Natural Indirect Effects both Short and Long Term:

The Roaded Natural designation provides for an environment that is naturally appealing with moderate evidence of the sights and sounds of people. This designation also states that such evidence usually harmonizes with the natural environment.

Under the No Action alternative, the setting for which this designation provides for would be negatively impacted both in the short and long term. Short term construction activities would exceed a moderate level of sights and sounds of human activities and constructed well pads would negatively impact a naturally appealing environment.

In the short term, the sights of construction traffic, construction noise, and other construction activities will negate the purpose of the Roaded Natural designation which is to provide a natural setting with only moderate evidence of human activity. Human activity associated with well pad development will escalate beyond the intended levels and recreational visitors will be negatively impacted by high levels of noise and disruption not associated with the Roaded Natural experience. In addition, this level of disruption will not be harmonious with the natural setting as called for under this designation.

In the long term, constructed well pads will detract from the natural environment by introducing highly industrial equipment and paraphernalia in an otherwise natural setting as described under this designation. Visitor experience will be intruded upon by such development when seeking the opportunities and settings the Roaded Natural designation provides.

On the Impact Intensity rating, the indirect negative impacts caused by the No Action alternative on the Roaded Natural designation would fall under Major Adverse for as long as the wells are in place. The recreational opportunity spectrum will be altered by this alternative and the Roaded Natural definition will no longer apply to the natural setting it requires.

No Action Alternative Roaded Natural Cumulative Effects

Given that Roded Natural makes up only 7% of the Pawnee National Grassland, it is a scarce resource on the Grasslands. Over time and in the foreseeable future, as more well pads are developed within the Roded Natural area, the more this scarce resource will be diminished.

The Roded Natural classification defines a user's experience to be one that is naturally appealing with only moderate evidence of people. It also restricts development levels so that the user's experience is retained at that level. Oil and gas development is not compatible with this definition as it introduces development that is not naturally appealing given its industrialized purpose. If oil and gas development encroaches on this ROS portion of the Grassland, the restriction on development will be annulled and the experience level it provides will be lost. Since this ROS level is not defined on any other portion of the Grasslands, the loss would be significant.

On a broader scale, aside from the loss of Roded Natural acres on the Pawnee National Grassland, it would also be a loss of Roded Natural acres for the entire Arapaho and Roosevelt National Forests. The Forest and Grasslands have predetermined areas and acres assigned to each ROS class. The loss of Roded Natural acres would decrease the total acres of Roded Natural across the entire Forest in addition to the Grasslands.

The Impact Intensity would fit into the Major Adverse category. This alternative would have a detrimental effect on the Roded Natural ROS class by reducing a limited resource even further while the well pads are in place.

No Action Alternative Rural Indirect Effects both Short and Long Term:

To be designated as Rural in the ROS, the natural environment is culturally modified yet attractive (i.e. pastoral farmlands) and allows for backdrops that may range from alterations not obvious to dominant.

Under the No Action alternative, oil and gas development will have moderate effect on the Rural designation since this designation allows for alterations to the landscape that can be dominant. While this ROS class allows alterations that can be dominant however, it also defines the environment as culturally modified yet attractive. The No Action alternative would negatively impact this criteria by introducing an environment that is industrially modified versus culturally modified.

In the short term, well pad construction activities will have a negative impact on the Rural ROS by introducing activities not congruent to a natural environment even if culturally modified. Noise, dust, traffic congestion, and the progressive assembly of industrial infrastructure will infringe on the natural character of the Rural classification by detracting from the sense of place this ROS classification provides.

For the long term, established well pads will alter the landscape more than intended by this classification which emphasizes a rural setting. Cultural development is within the

scope of this classification, but industrialized development is not. Cultural denotes development that is agricultural in nature versus development that is industrial in nature such as oil and gas development. This will ultimately alter the landscape from a rural sense of place to one that is more engineered in nature. The Rural classification is meant to offer recreational visitors a natural environment devoid of such development. As such, oil and gas pads will diminish the user's recreational experience overall.

On the Impact Intensity rating, the impacts to the Rural classification by the No Action alternative would fall into the Moderate/Major Adverse categories. This classification does allow for alternations in the backdrop that may be dominate, however such alternations are meant to be more cultural in nature than developed. This rating would remain applicable while the wells are on the ground.

No Action Alternative Rural Cumulative Effects:

Oil and gas development may dissuade visitors who are seeking a rural sense of place from visiting areas on the Grassland that have commercial development. As more development takes place, the more the sense of place characterized by this ROS classification is diminished. This may result in visitors traveling to other parts of the Grassland to find this experience as 93% of the Pawnee falls under this classification. This could increase user impacts in other areas of the Grasslands.

Given that 93% of the Pawnee falls under the Rural ROS class, the vast majority of all of the current oil and gas development has already taken place within this ROS designation. This puts additional pressure on the remaining acres to provide the level of user experience prescribed under this ROS class. As oil and gas development continues to take place within this ROS classification (which is all of the Pawnee except for the 13,335 acres of Roaded Natural), the more the level of development will exceed the experience level intended by this designation. This makes the Rural ROS designation obsolete depending on where oil and gas development takes place.

For the Impact Intensity scale, the cumulative impacts under the No Action alternative would be moderately adverse as some natural setting would still be provided under this alternative. This rating would be in effect for as long as the well pads are on the ground and before reclamation.

Developed Recreation:

The Crow Valley Recreation Area and the Pawnee Buttes SIA, in which the Pawnee Buttes Trailhead is located, are not available for leasing as directed by the 1997 Forest Plan decision.

No Action Alternative Developed Recreation Indirect Effects both Short and Long Term:

In the short term, there would be no construction activities associated with well pad development. The recreation experience and camping opportunities at the Crow Valley

Recreation Area will remain undisturbed under this alternative and the opportunities provided at Pawnee Buttes Trailhead will also remain undisturbed. Recreationists seeking these facilities will not be hindered by construction traffic nor other activities that accompany the development of oil and gas pads.

In addition to the recreational setting, the developed facilities at these locations will also remain protected. The Forest and Grasslands have spent considerable capital improvement funds to construct these facilities and spend funds every year to maintain them. Should these facilities become damaged or impacted during construction efforts, the cost of repair and maintenance would increase, putting financial strain on the managing unit. The No Action alternative prevents this from happening and continues to protect the capital improvements the Forest Service has invested in at these facilities.

There will be no negative indirect effects in the short term by this alternative because there will be no construction activities taking place.

In the long term, developed wells pads will not infringe on either developed site since development is prohibited within these areas.

The no leasing designation would keep the values associated with the camping and trailhead experience intact while also protecting capital improvements and investments at these facilities. There would be no negative indirect effects to these recreation resources under the No Action alternative.

It is a positive that this alternative protects the recreation experience at both The Crow Valley Recreation Area and the Pawnee Buttes Trailhead by not allowing the impacts of oil and gas development. The intensity scale would rate as negligible however because there would be no change to these recreation components from the No Action alternative.

No Action Alternative Developed Recreation Cumulative Effects:

Despite the fact that the developed recreation sites on the Pawnee are not available for leasing, there would still be cumulative effects resulting from this alternative. These impacts would result from the development of lands already leased within the vicinity, or from the future leasing and development of surrounding non-forest lands. Consequently, there are lands near these sites that are available for leasing or are already leased. If these adjacent lands were to be developed, the primitive outdoor experiences offered at both the campground and trailhead would be impacted by the introduction of mechanized equipment and industrialized machinery into the close by environment.

The Crow Valley Recreation Area offers not only the single developed camping opportunity on the Grassland, but also a bird watching route within its boundaries that attracts various types of birders. Well development within visibility on the adjoining land would serve to detract from the natural setting and sense of place normally associated with primitive camping experiences such as that found at Crow Valley. This detraction could decrease visitation to the site for which it was intended and may displace

recreationists to other areas of the Forest with developed campsites. Likewise, the opportunity cannot be replaced in kind because the Crow Valley Recreation Area has the only developed campground within the area or on the Forest that offers a grassland type setting and developed bird watching opportunities within its boundaries.

The Pawnee Buttes Trailhead would also yield similar cumulative effects in that the sense of place would be negatively impacted and the feel of wide open spaces would be encroached upon by well placement within its vicinity. Trail users may displace to other areas of the Forest as a result however, as is with Crow Valley Recreation Area, this developed trailhead is within (and accesses) a unique area with natural features and characteristics that cannot be found within the vicinity or elsewhere on the Forest.

On the Intensity Scale, the cumulative impacts would rate as Major Adverse under this alternative for as long as the well pads are in place. The Forest Plan designated these areas as non-leasable in order to protect the activities and special settings these two areas provide. The cumulative impacts would change the character of these sites for which they were granted that protection.

Dispersed Recreation

The No Action alternative does not provide stipulations for oil and gas activities for the dispersed recreational activities being analyzed under this study. Dispersed recreation includes:

No Action Alternative Motorized Recreation:

The Pawnee National Grasslands offers one designated Off-Highway- Vehicle (OHV) area for motorized enthusiasts. The Main Draw OHV Area provides a two-mile long draw or gully which is popular for various types of off road vehicles. Use numbers average between 30 to 50 riders a day per weekend with an open period of November 1 to April 9 (use data is currently not available for weekdays). Forest Plan direction for the Pawnee Nation Grasslands also provides direction to maintain this opportunity.

No Action Alternative Motorized Recreation Indirect Effects for Both Short and Long Term:

In the short term, motorized recreation may be negatively impacted by traffic congestion related to well pad construction. These impacts will depend on where those pads are being constructed and if they impede access to the OHV area. This negative impact will result from the obstruction of use for which the area was designated for.

In the long term, if a well pad is constructed within the OHV area itself, the use will be negatively impacted by the loss of opportunity proportionate to the acreage occupied by the well pad or pads.

For both short and long term effects, the impact intensity rating would rate at Major Adverse depending on well pad placement in relation to the Main Draw OHV area. If a well pad is placed within the OHV area, it will equate to the loss of land available to motorized use within restricted boundaries. The rating would remain as Major Adverse for as long as the well(s) remained within the OHV area.

No Action Alternative Motorized Recreation Cumulative Effects:

If final well pads are located in a way that causes the loss of the motorized opportunity within the designated OHV area, motorized users may displace to other areas in search of similar opportunities. Illegal off-road routes may be created and new impacts may be introduced into other areas of the Pawnee currently not experiencing such resource impacts. Ultimately however, the topography of the Grasslands is not favorable for replacing the opportunity lost at the OHV area. This equates to a once designated opportunity being completely lost. In addition, this will also result in users disbursing to other areas of the Arapaho-Roosevelt National Forest. Resource impacts, user conflicts, user congestion, and impacts to roads will increase in other areas of the Forest because of this displacement. Current motorized issues will increase along known OHV opportunities and new issues will be created as new areas are discovered for this use throughout the Forest for as long as the well pads are in place on the ground.

On the Impact Intensity scale, cumulative effects to motorized use will rate at Major Adverse for the reasons stated above.

No Action Alternative Bird Watching:

Bird watching is one of the two highest uses on the Grasslands, recreational shooting being the other. Over 3,000 people visit the Grasslands for this activity in addition to the 300 client days offered by special uses permittees offering bird tours throughout the year. The Pawnee is an internationally known destination for birding activities. It offers several different species of birds, including those unique to the grassland, for birding enthusiasts to enjoy. The Pawnee has been featured in various online publications specific to birding, including the Cornell Lab of Ornithology. The Audubon Society has also designated the Pawnee National Grasslands as an important birding area in 2000 making it an integral part of global bird conservation. There is a 21 mile self-guided bird route, several concentrated bird watching areas, and outfitter guides that offer paying customers birding tours through special use permits from the Forest Service.

The No Action alternative does not provide stipulations to cover bird watching and so offers the following effects to birding on the Grasslands:

No Action Alternative Bird Watching Indirect Effects for Both Short and Long Term:

In the short term, construction activities can negatively affect bird watching activities in various ways.

Increased traffic along roads used to access birding areas could lead to traffic congestion, possible traffic delays and impeded access to the viewing areas. Dust from increased traffic on newly constructed or existing dirt roads may interfere with visibility of the birds. Construction activities may also scare birds away from popular viewing areas as well. Noise from the construction sites will also degrade the quality of the recreation experience by disrupting the natural environment in which birding occurs on the Grassland.

Under the No Action alternative, if construction site access is established along the designated bird touring route, traffic will negatively interfere with bird watching by creating disturbance along the route in the same manner as mentioned above.

In the long term, the bird watching experience will be altered for as long as the well pad is in place. With no stipulations for the concentrated bird watch areas or along the bird route, viewing will be obstructed, specifically sought birds may avoid the area, and the bird watching experience will be degraded as the landscape is transitioned from a rustic sense of place to a more commercial one. Along the self-guided bird route, there will also be the permanent loss of interpretive stops depending on where the wells are located along the route and if the birds being interpreted at that stop begin to avoid the area.

For short term and long term effects, the No Action alternative will rate at Major Adverse on the intensity scale. The effects would be highly detrimental to the recreational activity of bird watching on the Grasslands. The effects would lead to loss of opportunity by obstructing views, potentially scaring away specific birds from viewing sites (including birds unique to the Grasslands), and by changing the character of the environmental setting in which the birds are observed.

No Action Alternative Bird Watching Cumulative Effects:

Both the concentrated birding areas and bird route have acreage in areas already leased for oil and gas in addition to leasable land. Under the No Action alternative, there would be no stipulations safeguarding bird watching from oil and gas activities. This means cumulative impacts to birding would result from two different scenarios. The first being well pad development on new leases and the other from well pad development on lands already leased. The cumulative impacts would affect birding in two different aspects. The birds may be affected which would change birding opportunities and the watching activities themselves would be impacted even if the birds were not.

Depending on placement on adjacent lands, as newly constructed well pads affect birding either by altering views, obstructing access, changing the sense of character of the landscape, or by affecting the birds specifically sought, the more the activity becomes degraded leading to a loss of visitation. Likewise, if bird species relocate to avoid well pads, they may become inaccessible depending on where they relocate to. As such, the current opportunity becomes lost. Birders may be able to go to other parts of the Forest to view some species, but other species can only be found on the Pawnee National Grassland. Furthermore, aside from the birds in particular, the birding habitat and

environment of the open prairie grasslands and buttes in which the birders engage their activity giving a particular sense of place is also irreplaceable elsewhere on the Forest. The cumulative impacts also become significant because of the special designation the Pawnee holds as a distinctive birding place. It is the Pawnee itself that draws birding enthusiasts for this activity. No other place has this distinction in this part of Colorado.

Aside from the loss of opportunities, the Pawnee also stands the potential of losing its status as an internationally recognized place for birding depending on where the wells pads are located and how many of them are placed within or adjacent to popular birding areas.

For the Impact Intensity rating scale, the cumulative impacts of the No Action alternative rate as Major Adverse for as long as well pads impact this recreation component before being reclaimed (up to 50 years per the assumptions).

Hiking:

Hiking is a limited resource on the Grassland. There are only two short trails in the Crow Valley Recreation Area known for their bird watching opportunities, and one longer hiking trail at a mile and a half long that transverses along the Pawnee Buttes Special Interest Area.

No Action Alternative Hiking Indirect Effects for Both Short and Long Term:

The aforementioned trails are located within the Crow Valley Recreation Area and the Pawnee Buttes SIA, which are not available for leasing per the 1997 Forest Plan decision. Because all of the designated hiking trails are completely contained within areas not available for leasing, there are no short or long term indirect effects from oil and gas activities on hiking.

While it is a positive for these recreation components to be in areas not available for leasing, the intensity scale would rate as negligible because there would be no change to these resources from the No Action alternative.

No Action Alternative Hiking Cumulative Effects:

Despite the fact that the official hiking trails are on lands not available for leasing, there would still be cumulative effects resulting from this alternative. These impacts would result from the development of lands already leased within the vicinity, or from the future leasing and development of surrounding non-forest lands. Consequently, all lands surrounding these sites are available for leasing or are already leased. If these lands were to be developed, the hiking experience would remain however it would become characterized by the sights and sounds of developed oil and gas facilities depending on where the newly developed pads are located. The trail within the Crow Valley Recreation Area and Campground would be more impacted since there is less distance from where a well can be located to the trail itself. The Pawnee Buttes Trail on the other

hand stands a better chance of being buffered from oil and gas since it is within a larger area that is not available for leasing, again depending on well placement.

People tend to hike on public lands for the feeling of being outdoors and being away in nature while traversing a natural landscape. The presence of oil and gas machinery will detract from that experience by intruding on the surrounding natural and open landscape of the Pawnee. In Crow Valley, this may also mean disrupting nature activities such as bird watching along the trail depending on where the well pads are constructed. This may lead to some displacement of hiking to other trails on the Forest. Additionally, since hiking on developed designated trails within the Pawnee is a scarce opportunity, the impact of oil and gas becomes more intensified as it affects a limited resource with no opportunity to replace it within the entire Grasslands given that these trails are access for popular destination points (i.e. the Buttes and bird watching in Crow Valley).

On the Intensity Scale, the cumulative impacts would rate as Moderate Adverse under this alternative. Some of the hiking experience may be buffered however the effects become more significant by affecting an opportunity which is scarce to begin with.

Recreational Target Shooting:

Recreational target shooting is the heaviest recreational use on the Pawnee National Grasslands. Use numbers range from 150 to over 200 recreational shooters a day on weekends alone spread over the year (use data is currently not available for weekdays). The use is generally concentrated in specific areas on the Grassland, but evidence can be found widespread as well. The Pawnee National Grassland has one designated range, the Baker Draw Designated Shooting Area, with limited amenities that serves recreational shooting enthusiasts from local communities and the urban population of Denver.

No Action Alternative Recreational Target Shooting Indirect Effects for Both Short and Long Term:

In the short term, construction activities could negatively impact the Baker Draw Shooting Area by impeding access to the shooting area if well pads are being constructed in close proximity. Dust caused by construction traffic and activities would also create visibility issues with sighting targets.

Depending on well pad construction locations, recreational shooters who prefer to target practice in more undeveloped areas may also be negatively impacted by the No Action alternative. Again, access could be disrupted to popular areas where people like to shoot and dust could interfere with the visibility of targets. In addition, newly constructed roads will reach into and open new areas to shooting. This will introduce new impacts to areas not currently affected by recreational target shooting. Some of these impacts will include newly introduced trash issues, safety issues in areas not appropriate for safe target shooting, and possible impacts to other resources such as wildlife.

In the long term, if a well pad is constructed within the boundaries of the designated shooting area itself, the recreational shooting opportunity will be negatively impacted by the obstruction and loss of use the area was intentionally designated for. Another impact would not be to the shooting opportunity but to the well pads as some recreational target shooters may use them as targets, or to place targets on.

Target shooting in other popular non-designated areas of the Grassland would also be impacted in a similar manner. If well pads are located within the area people like to shoot, the shooting opportunity would be reduced by the factor of the well pad placement. Recreational shooters may also use the well pads as targets as described above.

Similar to the short term impacts, newly established roads used to access the well pads will open access to new shooting areas. This will introduce new impacts to areas not currently affected by recreational target shooting as described above.

In both the short and long term, the recreational shooting impact intensity rating would measure moderately adverse to dispersed shooting. While the non-designated areas popular for shooting would be adversely impacted as described, the opportunity would not be lost because the Pawnee is completely open to shooting and shooters can find other areas to recreate in unhindered by oil and gas activities. On the other hand, this opens up new areas to the impacts associated with recreational target shooting (trash, safety, inappropriate shooting behavior, and infrastructure damage).

In the long term however, well pad locations could permanently alter the Baker Draw designated shooting area if they are located within its boundaries. This would have a rating of Major Adverse on the recreation site.

No Action Alternative Recreational Target Shooting Cumulative Effects:

Oil and Gas development will have cumulative impacts on recreational target shooting from the No Action alternative. These impacts will generally be caused by displacement and increased issues resulting from shooting as more well pads are built over time.

If any of the newly constructed well pad locations from new leases encroach on target shooting activities at the Baker Draw Designated Dispersed Shooting Area, recreational shooters will look to other areas on the Pawnee for places to target practice. These areas may include those already popular for shooting, or newly discovered areas where there are less obstructed shooting opportunities from oil and gas activities and infrastructure. If the undesignated areas popular for shooting are also impacted from well pad placement, those shooters, in addition to those from the designated shooting area, will both be looking for new opportunities on the Grasslands, resulting in further displacement of shooting activities over a wider area or to newly created concentrated shooting areas on the Grasslands. Newly constructed roads to access well pads will also attract shooting by opening access that was not available before.

There is also the consideration that oil and gas development on adjacent lands already leased, in conjunction with newly leased lands, will put higher rates of additional pressure on areas not yet being used by shooters. This will further direct target shooting and its associated impacts into areas otherwise free of, or that experience little effects from shooting currently.

Bearing in mind that the Pawnee Grasslands consists of only 192,800 acres, but serves a population of over three million people from local communities and the Denver metropolitan area, target shooting opportunities on the Pawnee will become further impacted as the demand grows from more people getting involved in this activity or by discovering the Pawnee for the first time. Combine this trend with the impact of oil and gas production on concentrated non-designated shooting areas in addition to the designated shooting site and the availability of alternative places to shoot becomes more constrained since there is only a limited amount of land for this opportunity to expand on. Another consideration will be that new users to the Pawnee will also avoid areas of oil and gas production facilities which will focus additional users into new areas not previously exposed to shooting. This will result in the expansion of shooting impacts across the Grasslands and the formation of newly concentrated shooting areas. The use may also push into areas that may not be appropriate for the activity which will create further conflicts which are already high. Even without the increased pressure of displacement and new discovery, the Pawnee experiences conflicts from recreational target shooting at an extremely high rate. This is the highest use on the Grassland and issues such as safety, trash, and property damage continue to escalate as does the popularity of shooting on the Grasslands.

As the population of shooters continues to grow in a highly populated portion of Colorado, shooting opportunities outside of the Grasslands are becoming increasingly scarce as well. Private ranges are at capacity with long wait lists, newly built facilities fill fast and the vast amount of public land other than Forest Service prohibits recreational shooting (such as Boulder County). Nearby Ranger Districts are also closing lands to shooting because of increasing safety issues and conflicts. The rising scarcity of places to shoot further escalates shooting pressure on the Grasslands.

Together with the displacement impacts of the No Action alternative, development on adjacent leased lands, the shooting demographic on the rise, and the growing scarcity of shooting opportunities in the surrounding areas, the Pawnee will see an increase in all areas of target shooting issues. Some of these impacts will include increased trash, increased impacts to infrastructure, increased safety issues, increased illegal shooting from newly constructed roads, increased user congestion, and increased conflicts with other Grassland users such as ranchers.

On the intensity scale, the No Action alternative will have a rating of Major Adverse per this discussion.

Recreation Special Uses:

There are seven special use permits on the Pawnee National Grasslands. Six of those permits are for commercial bird watching tours offering 300 client days throughout the year and one is for a recreation event launching rockets.

No Action Alternative Recreation Special Uses Indirect Effects for Both Short and Long Term:

In both the short and long terms, construction activities and the resulting well pads will have similar effects on permitted bird watching opportunities as discussed in the Bird Watching section of this alternative analysis (please refer to the Bird Watching section under the Dispersed Recreation heading for a more detailed discussion of the specific impacts). In turn, this would lead to a decrease in the quality of experience permittees offer their clients which would negatively impact their business. As special-use permit holders are impacted, this will also negatively affect the general public seeking a guided bird-watching experience on the Grasslands if such opportunities are reduced or lost.

With respect to recreational events, the short term effects may include hindered access to the event site depending on where construction activities are taking place. Effects in the long term will also depend on if a well pad is placed on the location where the event takes place. If this were to occur, then the event location would be lost to the permitted activity.

For short term and long term effects, the No Action alternative will rate at Moderate Adverse on the intensity scale for the reasons discussed above.

No Action Alternative Recreation Special Uses Cumulative Effects:

Since all but one of the special use permits on the Pawnee National Grasslands are for bird watching, the cumulative effects will be similar to those discussed in the Bird Watching section of this alternative. As these effects take place and birding opportunities are either degraded or reduced, special use permittees could see a decrease in their businesses as well as in the opportunities that they can offer the public. There would mean a decline in the demand for future permits if birding opportunities degrade or decline from oil and gas activities under this alternative.

There would be no cumulative effects for current or future recreation event permits. Other permitted activities can find or move to locations where oil and gas infrastructure is not a concern, if it is at all to the event.

Under the Intensity scale rating, the cumulative effects to special use permits would rate as Moderate Adverse as birding permits would be affected similar to the dispersed birding opportunities discussed previously, however other recreation permits would not be impacted by this alternative other than by possibly having to move locations.

Scenic Byways:

Forest Plan management direction places Scenic Byways under the NSO stipulation. The purpose of the stipulation is to protect the scenic values and settings for which the areas were designated. The Forest Plan goes on to say that the scenic resource is an important part of the visitor's experience on these popular routes, and the detrimental effects caused by oil and gas development in the foreground are not compatible with the management area emphasis.

No Action Alternative Scenic Byways Indirect Effects for Both Short and Long Term:

As with RNAs and SIAs, Scenic Byways possess characteristics worthy of special designation. The designation process to appoint these special routes is a national process in which certain criteria must be met, including recreational values. The NSO stipulation protects recreational values of these routes by prohibiting surface occupancy that would infringe on the characteristics for which the byway was nominated. For recreation, these include exceptional opportunities for recreation activities such as scenic viewing, driving for pleasure, and outdoor recreation opportunities. For the short and long term, the No Action alternative would protect scenic byways and the special values they offer.

In the short term, construction activities required by well pad development would not occur under the NSO stipulation in this alternative. Recreational opportunities provided by the Pawnee Pioneer Trails Scenic Byway would remain intact without the intrusion of construction traffic on or along the Byway, dust obscuring scenic values, or the sights of industrial construction activities within the view shed.

Activities associated with oil and gas construction efforts are not congruent with the management emphasis for this unique resource as currently directed by the Forest Plan. Without the NSO stipulation, Forest Plan direction would be violated and out of mandate. Forest Plan direction is vital in protecting the qualities of the Scenic Byway and providing management direction on what is acceptable and to be emphasized within these corridors.

For the reasons stated above, the No Action alternative would have no negative indirect impacts.

In the long term, there would be no well pads in place to diminish the character of the Scenic Byway. All of the recreational opportunities provided for by the Scenic Byway would remain unchanged and their unique values protected from the introduction of industrial equipment into and along the scenic landscape. As such, this alternative would have no negative indirect impacts on the recreational values provided by this specially designated Scenic Byway or on the Scenic Byway itself.

In the long term, the presence of well pads would also not be congruent with the management emphasis for this resource as directed by the Forest Plan. Without the NSO

stipulation, Forest Plan direction would be violated and out of mandate. This will contradict the protections and management direction of the Forest Plan for this Scenic Byway.

The NSO stipulation provided by the Forest Plan for the Scenic Byway is positive because it prevents indirect effects to the Byway. On the Impact Intensity Rating however, this alternative would rate as Negligible because there is no change to the resource under this alternative.

No Action Alternative Scenic Byways Cumulative Effects:

There are six wells within the Scenic Byway corridor which were approved before the NSO designation stipulated in the Forest Plan. Three are currently plugged and one is due to be plugged in 2014.

In the same regard to other lands falling under the NSO stipulation, there would be no negative indirect effects from this alternative, but there would be cumulative impacts. These impacts would result from the development of lands already leased within the vicinity, or from the development of future leasing activities on surrounding non-forest lands. As such, there are lands along the Scenic Byway that are available for leasing or are already leased.

Cumulative impacts from oil and gas development would be significant to the Scenic Byway if wells pads are located within its view shed since this would degrade the scenic quality for which this Scenic Byway was originally designated. As a result, recreational activities such as driving for pleasure and scenic viewing would be degraded as the open prairie landscape is transformed into a more industrialized one (depending on well placement). For as long as the well pads remain in place, the recreational opportunities originally offered by the Byway will continue to be impacted by the industrialized infrastructure erected on either side of the Byway as new development takes place outside of the NSO boundary.

Because scenic byways are special designations with each having its own unique characteristics and special qualities, this opportunity cannot be substituted elsewhere on the Front Range. Once affected, there are no other alternatives meaning the impacts are irreplaceable and irretrievable until the well pads and associated infrastructure impacting the Scenic Byway are reclaimed.

It is also important to note that this is a National designation which means the impacts also affect a nationwide program. National Scenic Byways consist of approximately 9,000 miles across the United States. Each byway is selected based on its own set of archaeological, cultural, historic, natural, recreational, and scenic qualities. While the 128 miles of the Pioneer Trails Scenic Byway may seem insignificant to the system as a whole, it is the distinctive and unique qualities that this Byway brings to the system that gives it its significance. This makes the Pioneer Trails Scenic Byway a one-of-a-kind and important resource on the whole National Scenic Byway program since it was

selected for its individual qualities thereby putting the cumulative effects on a national scale.

On the Impact Intensity Rating Scale, the cumulative impacts would rate as Major Adverse.

No Leasing and Leasing with No Surface Occupancy Alternatives

The No Leasing alternative and Leasing with No Surface Occupancy alternatives (NSO alternative) will be analyzed together in this report. When analyzing the effects of oil and gas activities on the recreation resource, it is the surface use that affects recreational activities in various degrees and means. Since both these alternatives prohibit the occupancy and use of the surface for oil and gas activities on Forest Lands, the effects will be comparable across both alternatives. Please also see the No Action alternative for more detailed information about each recreation component.

Permits may be issued under both alternatives for some infrastructure, such as roads or pipelines to reach well pads, but this is only a possibility and is not certain.

As with corresponding effects across both alternatives, the effects will be similar across all recreational uses as well. This is because there will be no new well pad development affecting any one recreation use. As such, the effects disclosure for this alternative will be consolidated into one discussion for all recreation resource components.

The Crow Valley Recreation Area and the Pawnee Buttes SIA remain unavailable for leasing under both alternatives per Forest Plan direction.

No Leasing and Leasing with No Surface Occupancy Alternatives Indirect effects Short Term and Long Term Common for All Recreation Resource Components:

In the short term, there would be no oil and gas construction activities from either alternative since well pad development is not permitted under either alternative. Likewise, in the long term, there would be no well pads or associated infrastructure established on the lands within the RFD. Since there is no oil and gas surface development under these two alternatives, there will be no negative indirect impacts to any recreation component from either alternative.

On the Impact Intensity Scale, both alternatives would rate as Negligible to the recreation resource on the Pawnee National Grassland. Recreation resources would remain unchanged because no new impacts would be introduced. The values associated with recreational experiences such as, but not limited to, driving for pleasure, scenic viewing, , internationally acclaimed bird watching, hiking, and recreational target shooting, will remain intact, and the sense of place many visit the Pawnee National Grasslands for will remain undisturbed under these alternatives.

No Leasing and Leasing with No Surface Occupancy Alternatives Cumulative Effects

While the No Leasing and NSO alternatives do not produce negative effects on the components being analyzed, there are cumulative effects to consider from either alternative.

Neither alternative allows surface disturbance from oil and gas activities. This means that oil and gas companies will be forced onto surrounding non-restricted non-Forest lands for mineral extraction. In addition, surrounding lands already leased may also experience future development. Since all of these lands open for potential future development are adjacent to the lands identified as No Lease or NSO, there will be indirect and cumulative impacts to each component being analyzed under this study. Both alternatives will have comparable indirect and cumulative effects. The only variable will be the number of wells, or the locations of wells per alternative. This information however is not available for this analysis and is unknown. The No Leasing alternative will cause a 10% increase in the number of wells and well pads compared to the No Surface Occupancy alternative.

No Leasing and Leasing with No Surface Occupancy Alternatives Research Natural Areas (RNA) and Special Interest areas (SIA)

As the adjoining lands are developed under either of these two alternatives, the sense of place the RNAs and SIAs offer would be permanently altered. The open natural spaces these areas possess would appear encroached upon as the boundaries of the RNAs and SIAs are not readily apparent on the ground. The scenic values of these areas would be compromised as well pads pepper the landscape and break up view sheds around these areas, and the feeling of being out in nature would be compromised by the presence of engineered oil and gas development within in the vicinity of these undeveloped lands.

In terms of recreation values, the Pawnee Buttes is the most popular of these areas on the Grasslands. This is a destination place with unique characteristics that cannot be found elsewhere with the main attraction being the Buttes. Some popular activities in this area include hiking, equestrian use, and wildlife watching. This alternative will actually serve to intensify the described cumulative impacts to this particular SIA because the impacts are affecting a finite destination resource that is irreplaceable considering the opportunities sought there and it is the only place the Buttes exist within the Grasslands or on the Forest.

Under the Impact Intensity scale, the cumulative impacts would rate as Moderate Adverse based on the discussion above.

No Leasing and Leasing with No Surface Occupancy Alternatives

The Recreation Opportunity Spectrum (ROS):

Both Roaded Natural and Rural designated areas are intended to provide a recreation environment that is natural appealing. As development occurs on areas adjacent to these lands, the sense of a naturally appealing environment will be degraded by the introduction of specialized equipment as the boundaries between Roaded Natural/ Rural with non-forest lands are not evident on the ground. This would only take place where the development can be observed from within the Roaded Natural or Rural designated areas.

The Impact Intensity would rank in the Minor Adverse category.

No Leasing and Leasing with No Surface Occupancy Alternatives Developed Recreation:

Despite the fact that the developed recreation sites on the Pawnee are not available for leasing under any of these two alternatives, there would still be cumulative effects.

The Crow Valley Campground offers not only the sole developed camping opportunity on the Grassland, but also a bird watching route within its boundaries that attracts various types of birders. Well development on the adjoining land would serve to detract from the natural setting and sense of place normally associated with primitive camping experiences such as that found at Crow Valley. This detraction could decrease visitation to the site for which it was built and intended and may displace recreationists to other areas of the Forest with developed campsites. The opportunity cannot be replaced in kind however because Crow Valley Campground is the only developed campground within the area or on the Forest that offers a grassland type setting in addition to the specified bird watching opportunities within its boundaries.

The Pawnee Buttes Trailhead would also yield similar cumulative effects in that the sense of place would be negatively impacted and the feel of wide open spaces would be encroached upon by well placement within its vicinity. Trail users may displace to other areas of the Forest as a result however, as is with Crow Valley Campground, this developed trailhead is within and accesses a unique area with natural features and characteristics that cannot be found within the vicinity or elsewhere on the Forest.

On the Intensity Scale, the cumulative impacts would rate as Major adverse for as long as the well pads remain in place. The Forest Plan designated these areas as non-leasable in order to protect the activities, facilities, and special settings these two areas provide. The cumulative impacts would change the character of these sites for which they are given that protection.

No Leasing and Leasing with No Surface Occupancy Alternatives Dispersed Recreation

Motorized Recreation:

As stated in the No Action alternative, The Main Draw OHV Area provides a two-mile long draw or gully which is popular for various types of off road vehicles. Use numbers average between 30 to 50 riders a day per weekend with an open period of November 1 to April 9 (use data is currently not available for weekdays).

The placement of well pads in lands adjacent to the Main Draw OHV Area will have no cumulative effects to motorized recreation at the site. There would be no change to this recreation component because the motorized activity does not require a scenic backdrop or similar sense of place with which the well pads would interfere. The opportunity would remain unhindered and un-impacted by the development of adjacent land.

On the Impact Intensity scale, cumulative effects to motorized use will rate at Negligible.

Bird Watching:

As stated in the No Action alternative, bird watching is one of the two highest uses on the Grasslands. Over 3,000 people visit the Grasslands for this activity in addition to the 300 client days offered by special uses permittees offering bird tours throughout the year.

The cumulative impacts from these two alternatives are significant because of the special designation the Pawnee holds as a distinctive birding place. It is the Pawnee itself that draws birding enthusiasts for this activity internationally. No other place holds this distinction in this part of Colorado.

Depending on placement, as newly constructed well pads on adjacent lands affect birding either by altering or obscuring viewing since they can be viewed across boundaries, changing the sense of character of the landscape, or by affecting the birds specifically sought (decreasing their number or forcing them to move), the more the activity becomes degraded leading to a loss of visitation. Additionally, if bird species relocate to avoid well pads, they may become inaccessible depending on where they relocate to. In the event their numbers decline because of oil and gas activity, then they are no longer able to be viewed, even if across boundaries. In either case, the current opportunity becomes lost since it cannot be found elsewhere. Birders may be able to go to other parts of the Forest to view some species, but other species can only be found on the Pawnee National Grassland. Furthermore, aside from the birds in particular, the birding habitat and environment of the open prairie grasslands and buttes where the birders engage their activity is also irreplaceable elsewhere on the Forest. This provides a specific sense of place that will be lost to birders who come for this internationally acclaimed opportunity.

Aside from the loss of opportunities, the Pawnee also stands the potential of losing its status as an internationally recognized place for birding depending on where the wells pads are located and how many of them are placed adjacent to popular birding areas.

For the Impact Intensity rating scale, the cumulative impacts of the No Action Alternative rate as Major Adverse.

Hiking:

Despite the fact that the official hiking trails are on lands not available for leasing, there would still be cumulative effects resulting from this alternative. If adjacent lands were to be developed, the hiking experience would remain however it would become characterized by the sights and sounds of developed oil and gas facilities depending on where the newly developed pads are located. The trail within the Crow Valley Recreation Area and Campground would be more impacted since there is less distance from where a well can be located on adjacent land in relation to the trail itself. The Pawnee Buttes Trail on the other hand stands a better chance of being buffered from oil and gas since it is within a larger area that is not available for leasing.

People tend to hike on public lands for the feeling of being outdoors and being away in nature while traversing a natural landscape. The presence of oil and gas machinery will detract from that experience by intruding on the surrounding natural and open landscape of the Pawnee. In Crow Valley, this may also mean disrupting nature activities such as bird watching along the trail depending on where the well pads are constructed. This may lead to some displacement of hiking to other trails on the Forest. Additionally, since hiking on developed designated trails within the Pawnee is a scarce opportunity, the impact of oil and gas becomes more intensified as it affects a limited resource with no opportunity to replace it within the entire Grasslands given that these trails access popular destinations (i.e. the Buttes and bird watching in Crow Valley).

On the Intensity Scale, the cumulative impacts would rate as Moderate Adverse. Some of the hiking experience may be buffered however the effects become more significant by affecting an opportunity which is scarce to begin with.

Recreational target shooting:

As stated in the No Action alternative, recreational target shooting is the heaviest recreational use on the Pawnee National Grasslands. Use numbers range from 150 to over 200 recreational shooters a day on weekends alone spread over the year (use data is currently not available for weekdays).

If adjacent lands were developed for oil and gas, a cumulative effect that may occur to recreational shooting is if well placement displaces target shooters from non-forest lands onto the Pawnee National Grasslands. This would serve to further increase target shooting issues currently experienced on the Grasslands. This is the highest use on the Grassland and issues such as safety, trash, and property damage continue to escalate as does the popularity of shooting on the Grasslands.

The number of displaced shooters would be expected to be low however because the majority of recreational shooting already takes place on the Pawnee National Grasslands.

Placing well pads on adjacent land will also encourage target shooting along the newly created roads constructed to access the new wells. This may change the use dynamic on the Pawnee as others may disperse from forest land to use these newly accessible areas. The change is expected to be inconsequential however because of the traditional use already established on the Grasslands by recreational target shooters.

On the Impact Intensity scale, cumulative effects to recreational target shooting will rate at Negligible.

No Leasing and Leasing with No Surface Occupancy Alternatives
Recreation Special Uses:

Since all but one of the special use permits on the Pawnee National Grasslands are for bird watching (offering 300 client days per year), the cumulative effects related to oil and gas development on adjacent land will be similar to those discussed in the bird watching section for these two alternatives (please refer to this section under the Dispersed Recreation heading). As the quality of birding degrades from the placement of well pads on adjacent land, special use permittees could see a decrease in their businesses as well as in the opportunities that they can offer the public. The public would also lose an opportunity to have guided tours or the level of customer service if permittees are forced to reduce business. There would also be a decline in the demand for future permits if birding opportunities degrade or decline from oil and gas activities under this alternative.

There would be no cumulative effects for current or future recreation event permits.

Under the Intensity scale rating, the cumulative effects to special use permits would rate as Moderate Adverse. The birding permittees would be affected in the same manner as dispersed birding opportunities however the other recreation permits would not be impacted by these alternatives.

No Leasing and Leasing with No Surface Occupancy Alternatives
Scenic Byways:

Cumulative impacts from oil and gas development would be significant to the Scenic Byway if well pads are located within its view shed since this would degrade the scenic quality for which this Scenic Byway was originally designated. As a result, recreational activities such as driving for pleasure and scenic viewing would be degraded as the open prairie landscape is transformed into a more industrialized one (depending on well placement). For as long as the well pads remain in place, the recreational opportunities originally offered by the Byway will continue to be impacted by the industrialized infrastructure erected on either side of the Byway as new development takes place outside of the NSO boundary.

Because scenic byways are special designations with each having its own unique characteristics and special qualities, this opportunity cannot be substituted elsewhere on the Front Range. Once affected, there are no other alternatives meaning the impacts are irreplaceable and irretrievable until the well pads and associated infrastructure impacting the Scenic Byway are reclaimed.

It is also important to note that this is a National designation which means the impacts also affect a nationwide program. National Scenic Byways consist of approximately 9,000 miles across the United States. Each byway is selected based on its own set of archaeological, cultural, historic, natural, recreational, and scenic qualities. While the 128 miles of the Pioneer Trails Scenic Byway may seem insignificant to the system as a whole, it is the distinctive and unique qualities that this Byway brings to the system that gives it its significance. This makes the Pioneer Trails Scenic Byway a one-of-a-kind and important resource on the whole National Scenic Byway program since it was selected for its individual qualities thereby putting the cumulative effects on a national scale.

On the Impact Intensity Rating Scale, the cumulative impacts would rate as Major Adverse.

Alternative Comparisons and Rankings

The No Action Alternative: High Risk

All of the three alternatives in this analysis provide stipulations on oil and gas development in relation to the RFD scenario. The No Action however only provides stipulations already prescribed in the Forest Plan where the other two alternatives provide more comprehensive coverage. The existing stipulations found in the Forest Plan do not encompass all of the recreation components making them susceptible to the impacts from oil and gas activities. When compared to the other alternatives, the No Action alternative has indirect impacts whereas the other two alternatives do not and it also creates more cumulative impacts when compared with the other two alternatives.

The No Action alternative also ranks as high risk because of these reasons.

No Leasing and NSO Alternative: Low Risk

There is very little comparison between the No Leasing and NSO alternatives explaining why they were analyzed together. They both have no indirect effects because surface occupancy and the resulting surface disturbance will not occur under either alternative. The No Leasing alternative does not allow leasing of any kind resulting in no surface occupancy, and while the NSO alternative does allow leasing, it stipulates that there will be no surface occupancy allowed. The difference between not allowing leasing and allowing leasing is the only discernible difference between these two alternatives. This provides no variance when analyzing the effects to recreation however because the

resulting no surface occupancy outcome is the same for both alternatives. The cumulative effects are also comparable between the two alternatives considering there is not enough information to differentiate them. Without knowing the location of the well pads and the number of well pads that will result on adjacent lands between the two alternatives, there is no way to distinguish them.

When compared to the No Action alternative, both alternatives provide for the greatest protection of the recreation resource by not allowing surface disturbance. They also do not generate as many cumulative impacts as the No Action.

Both alternatives would rank as low risk because they have no direct or indirect impacts to recreation. They both also provide the greatest protection for recreation that can be given from oil and gas activities.

3.13 Scenery

Introduction

The scenery resource analysis is used to identify and minimize the impacts of human caused development to scenery on National Forest lands. This resource is explicitly recognized in law. The National Environmental Policy Act of 1969 (NEPA) states that it is the “continuing responsibility of the Federal Government to use all practicable means to assure for all Americans, aesthetically and culturally pleasing surroundings.” NEPA also requires “a systematic and interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts into planning and decision making which may have an impact on man’s environment.”

Numerous other federal laws require all Federal land management agencies to consider scenery and aesthetic resources in land management planning, resource planning, project design, implementation, and monitoring. Several USDA handbooks have been developed to establish a framework for management of scenic resources. This report relies heavily upon *Landscape Aesthetics: A Handbook for Scenery Management*, USDA Forest Service, Agricultural Handbook No.701.

Landscape Aesthetics handbook discusses the “Scenery Management System which presents a vocabulary for managing scenery and a systematic approach for determining the relative value and importance of scenery in a national forest.” The system is to be used in the context of ecosystem management to inventory and analyze scenery in a national forest, to assist in establishment of overall resource goals and objectives, to monitor the scenic resource, and to ensure high-quality scenery for future generations. This handbook discusses many tools for which scenery resource specialists should employ, the best tools available are Scenic Integrity Objections (SIO).

The acceptable limits of change are the documented SIO’s, which serve as a management goal for the scenery resource. The Arapaho & Roosevelt National Forests and Pawnee

National Grassland (ARP) Land and Resource Management Plan (1997 Forest Plan) established acceptable limits of change for the scenery resource.

Components of oil and gas development with the highest potential to adversely affect scenery resources include the short term and long term appearance of well sites and production facilities, road construction, pipeline construction, and heavy vehicle traffic.

Issue Indicators

Potential future development of oil and gas leases might result in impacts to scenery. Impacts to the scenery resource will be measured in acres of scenic integrity objectives potentially impacted.

The frame of reference for measuring achievement of scenic integrity objectives is the valued attributes, such as vast open prairie and unique geological formations, of the existing landscape character being viewed. The project area includes High, Moderate and Low SIOs. High is defined as the valued landscape character “appears unaltered,” moderate is “slightly altered,” and low is “moderately altered.” Complete definitions can be found on page four of chapter two in the scenery handbook.

3.13.1 Affected Environment

The Pawnee National Grassland has evolved from its wide open prairie origins to more of a rural agricultural and pastoral setting. The Grassland is in the Great Plains Dry Steppe Province, more commonly referred to as the Central High Plains. Predominant vegetation is short and mid-grass prairie with cactus and sage common. Elevation ranges from 4,500 feet to 5,640 feet. Precipitation averages 9 to 17 inches annually, with 80% occurring during the spring and summer months. Temperatures tend to have a high degree of daily and seasonal fluctuation. Summer temperatures can reach over 100 degrees Fahrenheit with single digit humidity levels. Winter temperatures will commonly dip below zero degrees Fahrenheit. Persistent winds are very common year round and often gust over 30 miles per hour.

When precipitation events occur they move very quickly and produce heavy rainfall. The softer and more porous geology of this area has allowed erosion to work relatively quickly resulting in some steep sided mesas, bluffs, and creek bottoms. The best example of such erosion is the Pawnee Buttes which tower over the Grassland. The Buttes are the most recognizable symbol of the Pawnee National Grassland and one of the most visited locations. These areas of topographical interest are a key component to the valued landscape character of the Grassland.

With only minimal precipitation annually, most creeks are intermittent on the Grassland and can remain dry for years. Large cottonwoods populate these intermittent creek beds creating noticeably cooler micro-climates. For most of the year many bird species common to the Grassland are found in these creek bottoms which are few and far between. A few more notable bird species thrive outside of the protected creek bottoms

such as the Mountain Plover and Burrowing Owl. These birds are specifically adapted to the dry and windy landscape. The plains are also home to coyote and Pronghorn Antelope which can be found roaming all corners of the Grassland.

Agriculture and grazing have been present in this area since the late 1800s. A few remnants of this early subsistence farming and grazing culture are still present. Most of these remnants are farmhouses that were built over a hundred years ago and have not been inhabited for approximately the last sixty years. Agriculture and grazing remain a fundamental part of the surrounding communities' society and economy. An old barn or homestead are views into the past, giving glimpses of how life used to be on the Grassland. This feeling of time travel is a valued landscape character on the Grassland. Farming and ranching have been a part of this landscape since settlers came west on covered wagons in the latter part of the 19th century. Grazing cattle, remnant homesteads and barbed-wire fences are accepted components of the Grassland's landscape character. The project area is a valuable recreation area. The area is bisected by the Pawnee Pioneer Trails Scenic and Historic Byway which affords many pleasurable viewing opportunities. The Pawnee Buttes and associated trailhead are a popular destination along the Byway. The heaviest use occurs in late spring and early fall, but the area is accessible all year. Bird watching, dispersed camping, hiking and recreational shooting are the most popular recreational activities on the Grassland. Major access to the project area is provided by Colorado State Highway (CSH) 14 that intersects many county roads which lead further into the project area and facilitates wide spread recreational activities. This maze of roads degrades the valued landscape character.

Many of these dispersed recreational activities allow Grassland visitors to escape the congested urban setting. The vastness of the Grassland allows visitors to get away from it all, look in all directions and see only expansive prairie and imagine what it would have been like visiting here prior to human influences. This sense of escape is a valued landscape characteristic of the Grassland.

A relatively new sight on the Grassland is oil and gas surface activities. Oil and gas development has been more concentrated on the east side of the Pawnee National Grassland, and more specifically the southern portion near New Raymer. Oil and gas development has been less concentrated on the west side of the Grassland. Well pads tend to be areas cleared of all vegetation and have vertical structures such as pump jacks, tank batteries and above and below ground piping. Spill containment around the well heads tends to be highly reflective metal paneling. Newly constructed roads are a part of oil and gas activities. Semi-truck traffic has increased dramatically on Grassland roads which has had an adverse effect on scenic quality. Wells that are producing effectively often require pipelines stretching across the landscape to larger storage or production facilities. Pipeline trenches often require a path from the origin to its final destination which could be miles away. The introduction of this linear vegetation free path degrades the valued visual vastness for a term of approximately forty years, the time it takes native vegetation to re-establish.

Existing Scenic Integrity

As stated in *Landscape Aesthetics (Agriculture Handbook Number 701)* (pg. 2-1), “Scenic Integrity is a measure of the degree to which a landscape is visually perceived to be ‘complete.’ The highest scenic integrity ratings are given to those landscapes which have little or no deviation from the character valued by constituents for its aesthetic appeal. Scenic Integrity is used to describe an existing situation, standard for management, or desired future condition.”

In general, the Pawnee National Grassland would be rated as having a “Low to Moderate” degree of Existing Scenic Integrity. In some areas of the Grassland the landscape appears to be moderately altered by the vast road network and by surface-occupying oil and gas operations. These highly visible elements contribute to visual degradation of the valued landscape character and sense of place. The lack of vegetation and the presence of imported aggregate on the surface introduce colors, forms and textures not commonly found on the Grassland. The vertical elements of well pads occasionally borrow color from the surrounding landscape but introduce architectural styles not naturally associated with the Grassland. These non-natural deviations are even more prevalent on private land which increases the degradation of the overall valued landscape character.

The Grassland is a checker-board of private, state and federal lands, each with their own set of circumstances. Private lands tend to be developed first and with greater intensity. This increased level of surface activity adjacent to federal Grassland lands degrades the overall valued landscape character.

Scenic Integrity Objectives

The project area is described in the Forest Plan as having “High, Moderate and Low” Scenic Integrity Objective (SIO) areas. The table below shows the number of acres associated with each scenic integrity objective area within the project.

Scenic Attractiveness

“Scenic attractiveness is the primary indicator of the intrinsic beauty of a landscape and of the positive responses it evokes in people. It helps determine landscapes that are important for scenic beauty, based on commonly held perceptions of the beauty of landform, vegetation patterns, composition, surface water characteristics, and land use patterns and cultural features.” (*Agriculture Handbook Number 701* pg. 1-14)

The majority of the project area has an indistinctive classification (Class C) because it has a weak sense of variety, vividness, mystery, pattern and balance. The Grassland lacks a wide spread natural variety across the landscape and tends to be more homogenous and subtle natural patterns. Large expanses of rolling plains do not offer much natural contrast or examples of vividness to visitors. The lack of natural contrast across great landscapes does not arouse much curiosity when visitors can see a majority of the area that lies ahead of them. The existing land use patterns including oil and gas and Grassland roads have detracted from the existing scenic quality. Surface-occupying oil

and gas activities reduce the visitor's sense of unity and harmony by going against the presumed order or pleasant arrangement of natural elements. Visitors expect to see the undulating hills, wind-blown fields of prairie grasses and grazing herds of Pronghorn. They do not expect to see straight roads leading to well pads with introduced vertical elements and mechanical operations.

Certain portions of the project area do have distinctive elements (Class A) such as the Pawnee Buttes because of its unusual and unique scenic qualities. This is the only location on the Grassland where there is such natural contrast and vividness. This natural contrast and vividness is a key component to the valued landscape character.

Existing Condition Conclusion

The Pawnee National Grassland prior to westward development was characterized as being naturally vast, pastoral, homogenous, wind-swept, and secluded. Given that the natural landscape lacks much natural contrast and vertical structure, any deviation from these elements is usually seen as domination over the valued landscape character and the memorable sense of place it once created. This increased level of commercialized activity has degraded the valued landscape character on the Pawnee National Grassland.

Grasslands Land Management Areas

Management Areas (MAs) are a detailed description of each management area. The table below lists, in descending order, the magnitude in relation to the acreage of land covered along with their Scenic Integrity Objective (SIO).

Table 58 Management Areas on the PNG

Management Area (MA)	Acreage of Analysis Area	Percentage of Analysis Area	Scenic Integrity Objective (SIO)*
6.6 - Mid-Composition - Low Structure; Grassland Resource Production	122,511	63.6%	Moderate & Low
6.4 - Mid-Composition - High Structure; Native Shortgrass Prairie	51,209	26.6%	Moderate & Low
3.1 - Special Interest Areas - Emphasizing Use or Interpretation	9,526	4.9%	High & Moderate
4.2 - Scenery	4,920	2.6%	Moderate & Low
2.2 - Research Natural Areas	2,578	1.3%	High

3.61 - Prairie Woodland	1,339	0.7%	Moderate
4.3 - Dispersed Recreation	345	0.2%	Moderate
8.21 - Developed Recreation Complexes	121	0.1%	Moderate & Low
TOTAL Acres	192,549	100.0%	

3.13.2 Environmental Consequences

Methodology

Scenery resource impacts from oil and gas development result from the visibility of constructed elements of different form, line, color, and texture into the natural landscape combined with the distance at which proposed development is viewed and the concern of the viewer for scenic quality and integrity. The extents of noticeable change on the landscape as a result of project development will be measured in levels of effects to the scenic integrity (Major, Moderate, Minor, or Negligible).

Scenery Analysis Assumptions

Leasing is a commitment of the resource for potential future exploration and development, but leasing does not compel or authorize any ground disturbing actions in support of the exploration or development of a lease. As a result of leasing, future exploration and development proposals could be brought forward that would be subject to additional site specific environmental study and permitting requirements.

No alternative specifically proposes the physical exploration or development of oil and gas resources. For this reason, the leasing analysis relies on the reasonable foreseeable development (RFD), which projects potential future surface disturbing activities, to provide a development scenario that has been determined to be reasonable on the all lands (federal, state and private). However, this scenario is dependent on future industry interest, access, market values and many other factors. For the purpose of analyzing impacts on the Analysis Area, there is an estimated 13,041 new wells drilled on 8,742 well pads resulting in 44,440 acres of new disturbance in, near or around the PNG. Restricted to just the Project Area, the RFD projection is for 265 new wells drilled on 80 well pads resulting in approximately 960 acres of new surface disturbance. At this time there is no way of determining how many acres could be leased.

Any future exploration or development of oil and gas resources, if and when it does occur, would result in impacts. However, those impacts would not occur until some point

in the future and only following additional site specific environmental study and the federal leasing and development process.

The effects of post-leasing activities on the PNG scenery resources are generally related to surface occupancy and associated ground disturbance, activity, and the presence of unnatural elements such as drilling rigs, storage tanks, pump jacks, and roads previously not part of a landscape or view.

Past, Present, and Foreseeable Activities Relevant to Cumulative Effects Analysis

Past, present and foreseeable future actions in the Analysis Area influencing scenic conditions may include impacts from activities and/or actions associated with the following:

- Oil and gas development on previously leased federal lands, public and private lands
- Wind energy development on private lands
- Vehicle Use of current and future Roads
- Power-lines

Oil and gas development has occurred and will continue to increase in and around the Analysis Area on private lands and other lands (State and Federal) that have 100% private mineral rights. Development is more likely to occur on the eastern portion of the Analysis Area, with emphasis on the southern half of the eastern portion. Oil and gas development will likely have adverse effects on scenic quality directly related to constructed features (pipelines, power lines, well pads, drill rigs, associated roads, compressor stations, and production facilities) and activities.

Wind energy development has been occurring and may continue to increase in and around the Analysis Area. Development is likely to occur on private lands in the north half of the eastern portion of the Analysis Area. Wind turbines and transmission lines would likely have an impact on scenic quality due to the height of these units and the ability for these to be seen from great distances.

Vehicle use of current and future roads and associated dust will likely continue to increase in and around the Analysis Area. The increased traffic and associated dust will likely occur on both private roads and public roads. An increased level of dust present in the atmosphere will likely have adverse effects on scenic quality due to the reduced ability to view pleasurable landscapes.

Power-line development may continue to increase in and around the Analysis Area. Development will likely occur on both private lands and Grassland lands. Power-lines would likely have adverse effects on scenic quality due to the visibility of the structures in the middle-ground of some valued landscape views.

Alternative 1 – No New Lands Available for Lease

Direct Effects

The beneficial effects of Alternative 1 are the fact that there will be no modification of vegetation or soils associated with well pad construction, there will be no constructed features present on PNG lands, and there would be no drilling operations present on PNG lands.

Indirect Effects

A moderate adverse effect on scenery of this no leasing alternative would be the largest amount of surface development on private lands within the Analysis Area. Research provided by BLM states that this alternative would likely require approximately 10% more surface disturbance off national forest system lands, as compared to the NSO alternative. Another minor to moderate adverse effect of this increased private land development would be the increased heavy vehicle use of Analysis Area roads which will likely increase the amount of dust present in view-sheds.

Another minor to moderate adverse effect would be the increased intrusions on the night time scenery from private land oil and gas development such as flare-offs from well sites and drill rig lighting.

Cumulative Effects

All of the effects associated with this alternative would be the result of those previously leased lands. For this alternative all of the effects will result from previously leased lands that have or have not yet been developed, lands with 100% private minerals, or private lands. In combination with past, present and foreseeable future projects in and around the Analysis Area there would be minor adverse cumulative effects on the scenic quality of the grassland. However, the cumulative adverse effects of Alternative 1 would likely be less than Alternative 2 but more than Alternative 3.

Alternative 2 – No Action

Direct Effects

Extraction of subsurface resources requires the construction of a well pad. Oil and gas well pads may be 12 acres in size during initial construction (short term) and may be reduced to 1.5 acres after reclamation has been completed. Modification of vegetation and soils cannot be avoided and may have minor to moderate adverse effects to the naturally monochromatic landscape.

Well pads will usually include vertical constructed features such as storage tank batteries, separators, and may include a pump jack and associated gas-powered generator. These constructed features introduce lines, forms and textures that are not naturally occurring on the landscape. These deviations do appear visually subordinate to the valued landscape character when being viewed from greater distances. An active well

will remain in production on average 30 to 50 years resulting in long term minor to moderate adverse effects to scenery.

Road and pipeline construction would likely result in a minor to moderate adverse effects to the valued landscape. Effects would include minor color contrasts between the imported lighter colored road gravel and other areas of disturbance compared to the surrounding vegetation. Long and linear features such as roads and pipelines can be seen and identified in some view-sheds across the Grassland.

A temporary adverse effect is the presence of heavy construction equipment and increased large vehicle traffic on Analysis Area roads. The increased heavy vehicle traffic will probably lead to more dust present in the atmosphere which would reduce the distance to which visitors can see and would likely reduce the level of detail they can see in these valued vistas. The additional dust present in the view sheds would likely have a minor to moderate adverse effect on scenic quality.

Indirect Effects

Drilling rigs would likely introduce moderate to major line and form contrasts and may dominate the valued landscape character and may not borrow from valued landscape attributes, such as the vast low lying prairie and unique geological formations. The relatively tall structures may be seen from miles away and are immediately identified as a part of oil and gas operations. The adverse scenic impacts of drilling rig operations would be greater in areas visible from Concern Level 1 travel routes or viewpoints such as Hwy. 14, the Scenic Byway, and the Pawnee Buttes Trailhead and associated trails. Most of these moderate adverse effects would be temporary, lasting from approximately two to three months per well pad (BLM/USFS 2011).

Oil and gas operations may have moderate adverse effects on night time scenic characteristics. Flares from some well sites would have moderate adverse effects and be a major contrast and intrusion on the natural evening and nighttime horizon line. Night time lighting on the drilling rigs may be controlled to reduce the night time visibility of the derrick from a distance. Drilling rigs and compressor station's lighting may have some adverse effects on the vast darkness of the Grassland by introducing non-natural light sources that could interrupt the night time scenic qualities. Night time oil and gas lighting may be visible from long distances if not properly mitigated. The Colorado Oil and Gas Conservation Commission (COGC), which regulates oil and natural gas activities in Colorado, has direction on lighting, Rule 803 states *"To the extent practicable, site lighting shall be directed downward and internally so as to avoid glare on public roads and building units within seven hundred feet."*

Cumulative Effects

Oil and gas development (constructed features) and wind energy development (wind turbines) on adjacent private lands with their associated increased vehicles on roads and power lines all add to the direct and indirect effects of Alternative 2. This may result in

major adverse effects to High SIO areas, moderate adverse effects to Moderate SIO areas, and minor adverse effects to Low SIO areas.

Summary of Effects

High SIO has 6,728 acres of NSO in the Project Area for this alternative. Oil and gas operations would likely adversely affect high quality scenic resources if surface development was to occur on NFS lands with 100% private mineral rights within High SIO acres. The impacts to High SIO acres may be short-term to long-term with major adverse effects and may not meet the SIO as stated in the 1997 Forest Plan.

The potential scenery impacts to Moderate SIO acres in areas without NSO are 137,475 acres and may not meet the SIO as stated in the 1997 Forest Plan; this would be a minor to moderate adverse effect.

Low SIO applies to 2,171 acres of the Project Area without NSO. Oil and gas operations within Low SIO will likely have negligible to minor adverse effects to scenery resources.

Alternative 2 would have the greatest adverse effects on the scenic resources in the Project Area. It would be in compliance with 2,171 acres of Low SIO, and may or may not be in compliance with 144,203 acres of Moderate and High SIOs within the Project Area (See Table 57).

Alternative 3 – No Surface Occupancy on all PNG Lands

Direct Effects

The beneficial effects of Alternative 3 are the fact that there will be no modification of vegetation or soils associated with well pad construction, there will be no constructed features present on PNG lands, and there would be no drilling operations present on PNG lands.

Indirect Effects

A moderate adverse effect on scenery of this NSO alternative would likely be the increased surface development on private lands within the Analysis Area. Another minor to moderate adverse effect of this increased private land development would be the increased heavy vehicle use of Analysis Area roads which will likely increase the amount of dust present in viewsheds.

Cumulative Effects

Adverse cumulative effects of Alternative 3 would likely be less than Alternative 1 based on BLM research that states that this alternative would require approximately 10% less surface disturbance or development on private lands than Alternative 2.

Based on current research and findings, Alternative 3, no surface occupancy stipulation applied to all newly available PNG lands would be the preferred alternative in regards to maintaining or improving scenic integrity and quality.

Summary of Effects

Scenery Resources would be least impacted by Alternative 3 and second least impacted by Alternative 1, with Alternative 2 having the greatest risk for impacts to scenic resources. The effects for SIOs are summarized in Table 57.

Table 59 Scenic Integrity Objective Acreage Summary for Alternative 1

SIO	With NSO	Without NSO	% of Leasable Acres	Total Acres for Potential Disturbance
High SIO	0	0	0%	0
Moderate SIO	0	0	0%	0
Low SIO	0	0	0%	0
Total	0	0	0%	0

Source: PNG GIS data

Table 60 Scenic Integrity Objective Acreage Summary for Alternative 2

SIO	With NSO	Without NSO	% of Leasable Acres	Total Acres for Potential Disturbance
High SIO	6,728	0	4.59%	0
Moderate SIO	0	137,475	93.92%	137,475
Low SIO	0	2,171	1.48%	2,171
Total	6,728	139,646	100%	139,646

Source: PNG GIS data

Table 61 Scenic Integrity Objective Acreage Summary for Alternative 3

SIO	With NSO	Without NSO	% of Leasable Acres	Total Acres for Potential Disturbance
High SIO	6,728	0	4.59%	0
Moderate SIO	137,475	0	93.92%	0
Low SIO	2,171	0	1.48%	0
Total	146,374	0	100%	0

Source: PNG GIS data

Table 62 Scenic Integrity Objective Compliance by Alternative

SIO Compliance by Alternative	Alternative 1 No New Lands	Alternative 2 No Action	Alternative 3 NSO
High SIO	Meets	May Not Meet	Meets
Moderate SIO	Meets	May Meet	Meets
Low SIO	Meets	Would Likely Meet	Meets

3.14 Heritage

Introduction

The analysis of effects to cultural resources for the Oil and Gas leasing analysis focused primarily on determining the potential of the decision to adversely affect historic properties. Historic properties are defined in 36 CFR 800.16 (l)(1) as “any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places (NRHP) maintained by the Secretary of the Interior”. The relevant issue to the cultural resources analysis was whether the project might alter the characteristics of historic properties that make them eligible for the NRHP by diminishing the property’s integrity of location, design, setting, materials, workmanship, feeling, or association. Another valuable indicator when assessing adverse effects to historic properties is the potential loss of information important to history or prehistory. The overall analysis indicator for the project should be the potential effects to historic properties.

The spatial and temporal context for the effects analysis is defined in more detail in the environmental consequences section of the analysis and focuses on determining the area of potential effects (APE) of the proposed decision. The APE for the project was defined as all lands that were designated as administratively available for leasing under the 1997 ROD that have not already been leased. Additional adjacent lands were also considered for impacts to cultural resources under the oil and gas projections under the Reasonably Foreseeable Development Scenario to determine the potential effects to the integrity of setting and feeling and or potential cumulative impacts.

3.12.1 Heritage Affected Environment

The current knowledge base regarding heritage resources in the study area derives from archaeological surveys totaling 56,800 acres (30% of the PNG). Within the project area, there are 1,847 known prehistoric and/or historic archeological sites ranging in age from ca. 11,000 B.C. until historic times.

Prehistoric Sites

Prehistoric sites make up 70% (n=1307), historic sites make up 24% (n=460), and the remaining 6% of the sites (n=80) contain both prehistoric and historic components. Sites that are listed, eligible for listing or have not been fully evaluated for listing on the

National Register of Historic Places make up 17% (n=322) of the recorded cultural resources on the Pawnee National Grassland. The following summaries of prehistoric and historic sites on the Pawnee National Grassland were derived from the Forest Service spatial and tabular databases and the Office of Archaeology and Historic Preservation spatial and tabular databases in January of 2013.

Table 63. Prehistoric Cultural Resource Types on the PNG

Prehistoric Site Types	Count
Open Lithic Sites	331
Open Camp Sites	193
Stone Quarry or Lithic Procurement Sites	53
Stone Circle or Open Architectural Sites	34

Table 64. Historic Cultural Resource Types on the PNG

Historic Site Types	Count
Homesteads, Ranches or Historic Habitation Sites	125
Historic Ditches, Canals, or Water Control or Development Sites	16
Railroad Grades and Railroad Development Sites	14
Rural Schoolhouse Sites	2
1864 Battle of Cedar Creek Associated Sites	2
Civilian Conservation Corp and WWII Civilian Public Service Camp	1
Cold War Atlas E Missile Site	1
Resettlement Administration Headquarters Site	1

Prehistoric sites thus far recorded on the Pawnee National Grassland range from older than 11,000 years to approximately 150 years ago. Prehistoric research themes generally include questions about local chronology, individual site function(s), settlement patterns and site location variables, lithic procurement and preferential raw material selection strategies, lithic technology, and resource exploitation patterns (Eighmy 1984).

Site types within the Pawnee National Grassland primarily reflect hunting and gathering activities, stone tool manufacture, and habitation sites. Architectural sites may occur within the more well-watered drainages. These sites are represented by projectile points, grinding stones, butchering tools, other lithic (stone) debris, and pottery. Features such as rock-lined pit houses, lithic procurement sites (quarries), stone circles, and rock overhang shelters have been found. Prehistoric sites can be expected most commonly within ½ mile of water sources. Other predicted site locations are areas of rock overhangs and ridge tops that contain silicified rock deposits. Such deposits generally consist of cherty materials such as jasper which were utilized by Native Americans for stone tool manufacture. These sites can be very long, exceeding a mile or more in length.

Table 65. Cultural Components within the Prehistoric Chronology for the Platte River Basin

Cultural Component	Temporal Range	Identified Cultural Components on the PNG
Paleoindian Stage	12,000-7690 B.P.	2
Clovis Period	12,000-11,000 B.P.	1
Folsom Period	13,290-10,670 B.P.	1
Plano Period	12,800-7690 B.P.	0
Archaic Stage	7500-1800 B.P.	5

Early Archaic Period	7500-5000 B.P.	0
Middle Archaic Period	5000-3000 B.P.	15
Late Archaic Period	3000-1800 B.P. (A.D.150)	23
Late Prehistoric Stage	800-360 B.P. (A.D. 150-1540)	23
Early Ceramic Period	1800-800 B.P. (A.D. 150-1150)	19
Middle Ceramic Period	800-360 B.P. (A.D. 1150-1540)	6
Protohistoric Period	360-90 B.P. (A.D. 1540-1860)	11

Derived from (Gilmore et. al. 1999)

Historic Overview

The Open Range

The first cattle drive from Texas to what would become Colorado occurred around 1859. In the 1860s Cattlemen or cattle “barons” would purchase Texas cattle at low prices and drive them north to Colorado and Nebraska where they could fetch higher prices. The cattlemen and the cowboys they hired grazed for free on public domain lands often fencing public domain lands and guarding the water sources with line camps. The need for cattle was fed by the large demand of the booming mining development in the Colorado Rockies. Cattle Barons like John Wesley Iliff and John Wesley Prowers turned the cattle drives and grazing on public lands into large, lucrative, and influential industry. The drives became less profitable in the 1890s when cattle prices dropped and homesteaders were beginning to populate the area. The homesteaders were aided by congressional actions and an increase in sheep grazing in Weld County (Mehls 1984; Mehls and Mehls 2006; Ubbelohde 2006).

Homesteading

The earliest homesteading on and around the Pawnee National Grasslands slowly followed the designation of Colorado Territory in 1861 and the Homestead Act of 1862. Initial settlement of the area was slow during the period of the Civil War (Mehls and Mehls, 2006).

The Bureau of Land Management (BLM) Government Land Office Records indicate that the first settlers to the area purchased land parcels or used military scrip as authorized by the Scrip Warrant Act of 1855. The first homesteading occurred around 1891, but was slow to develop due to the arid condition of the lands that would later become the Pawnee National Grassland (BLM 2013). The arid condition of the lands was exasperated by the 1890s Colorado drought.

In the early 1900s beet farming was taking off west of the Pawnee National Grasslands alongside increasing water development projects. A beet boom was taking place by 1905 in the irrigated areas along the railroad in communities like Greeley, Eaton, Ault and Pierce (Holleran 2005). A rush of homesteaders to the grasslands occurred in 1909 and 1910 that coincided with unusually wet conditions, boosters that promoted development, and the enactment of the Enlarged Homestead Act of 1909, which allowed for patents of 320 acres in size to allow for dryland farming rather than the 160 acre parcels allowed for in the 1862 Homestead Act (Mehls and Mehls 2006; Koenig 1979; BLM 2013).

The early homesteads met the requirements to prove up their claim with sod homes or vernacular structures, small outbuildings and wells. The railroad expansion that connected the communities of Sligo, Stoneham, Buckingham, Keota, Grover and other

small towns to the resources in Cheyenne and larger Colorado Towns made it possible to obtain better building materials and build more larger and better built structures.

Homesteading in northeastern Weld County continued in high numbers through the 1920s. Congress spurred additional land patents by the enactment of the Stock Raising Homestead Act of 1916 which allowed for 640 acre parcels on arid lands for stock raising. Wartime needs during World War I also spurred development of marginal lands in northeastern Weld County. Existing Farms were not meeting demands and crop prices were rising.

The Great Depression and the National Grasslands

Although the land that became the Pawnee National Grassland was not part of the federally-designated Dust Bowl, the drought and economic depression of the 1930s had devastating effects on the marginal land farmers of Weld County, Colorado. The early 1930s saw several extremely dry seasons in northern Colorado. The homesteaders of the Great Plains had largely settled on “sub-marginal” land that was poorly suited for farm crops and had been living in poverty long before the 1929 stock market crash. Many newly unemployed factory workers had left cities during the early years of the Depression to attempt to make a living farming. Not only did the drought cause crops to fail, but removal of the native prairie vegetation and tillage of the dry soil made this marginal agricultural land extremely dry and unstable. In 1932 and 1933 the drought was accompanied by dry winds that churned up the loose dry soil and carried it away in dust storms.

In response to the high number of farm foreclosures and tax delinquencies, the federal government launched a land utilization program to purchase and develop sub-marginal land. This program eventually evolved into the Bankhead-Jones Farm Tenancy Act of 1937. A total of 11.3 million acres of land were acquired under these programs for an average of \$4.40 per acre. The acquired land was planted with grasses and trees, improved with flood and erosion control features, or used for roads, employing a great number of people at the same time that the land was improved. These lands changed agencies many times before finally being designated as National Grasslands in 1960(Olson 1997).

Existing Condition

The existing condition of cultural resources on the PNG is constantly changing. Continued archaeological inventories and discoveries increase the knowledge base for cultural resources. The broader knowledge base allows resources to be better evaluated for significance and put into a more refined historic and prehistoric context. At the same time that the resource knowledge base is augmented by continued research and documentation it is also being diminished by human and natural processes. Unauthorized collecting, theft, excavations, and vandalism occur now and will continue. Natural erosional and depositional processes will also degrade heritage resources. Land and resource management associated with recreation, oil and gas development, agriculture, and grazing are on-going. The projects associated with the land management activities have the potential to affect historic properties. Thirty percent of the PNG has been surveyed for cultural resources and approximately 2,000 cultural resources have been identified; approximately 300 of those are considered to be historic properties eligible for

the NRHP. The number of identified cultural resources is expected to increase, which will increase the number of resources that should be preserved, interpreted for the public, maintained, and documented.

Oil and gas development has the potential to directly impact cultural resources by causing physical destruction, damage, or loss of critical information about prehistoric and historic life during construction of wells, access roads, pipelines and other activities associated with oil and gas development. Oil and gas development also has the potential to impact the setting and visual landscape of cultural resources. Oil and gas development accessing federally owned mineral estates are subject to authorization and consideration of cultural resources through the NEPA and NHPA section 106 processes. Lease terms that are intended to minimize or remove potential impacts to cultural resources are applied when accessing federal oil and gas leases on Federal lands and private lands. Additional lease terms may also be applied to development of federally owned mineral estates where development takes place on federal lands. The existing impacts from oil and gas leasing accessing federal estates are restricted mostly to visual impacts to the setting cultural resources. Direct impacts are avoided or mitigated.

Privately owned mineral estates are not subject to federal authorization when development takes place on private lands. There are likely ongoing, direct, and irreversible impacts to cultural resources on private lands accessing private mineral estates. The loss of cultural resources and archaeological information diminishes the understanding of past human behavior.

Case law and regulations have been inconsistent on the ability of federal agencies to carry out environmental and cultural resource reviews for privately owned mineral estates where development will take place on federal lands (Williams 2011; Minard Run Oil Co. v. U.S. Forest Service; Minard Run Oil Co. v. U.S. Forest Service; San Luis Valley Ecosystem Council v. U.S. Fish and Wildlife Service). For a reserved private mineral right underlying National Forest System (NFS) lands the Forest Service does issue an authorization that triggers cultural resource review and consideration. For outstanding mineral rights underlying NFS lands the Forest Service may only have 60 days to respond to requests to access the underlying minerals and may not be able to give full consideration to cultural resources. The Archaeological Resources Protection Act (ARPA) does provide penalties for damaging archaeological resources. There are incentives for mineral estate owners, lease holders, and oil and gas development companies to avoid damaging cultural resources on Federal lands. In most cases consideration of cultural resources will take place for development of both reserved and outstanding mineral rights, although the authority to carry out reviews that could delay the mineral estate owner from development is currently unclear.

Desired Condition

The desired conditions for cultural resources is that they remain stable, intact, and the characteristics which make them eligible for the NRHP remain unaltered by future projects, neglect, forest visitors, or natural processes. Cultural resources should continue to provide interpretation opportunities to increase public understanding, appreciation, and perspective of our diverse heritage and provide opportunities for scientific and cultural study to gain knowledge about past human behavior.

3.12.2 Heritage Environmental Consequences

Methodology

Incomplete and Unavailable Information

The current knowledge base regarding heritage resources in the study area derives from archaeological surveys totaling 56,800 acres (30% of the PNG). A total of 35,002 acres (approximately 24%) of previous archaeological surveys have taken place on the lands currently being analyzed for a leasing decision (146,367 acres). In addition to a lack of knowledge of the resources in about three quarters of the analysis area, sites that were previously determined not eligible for the NRHP may need to be re-evaluated within the context of the current knowledge base. Periods and areas of historical and prehistoric significance can change over time. Recording and data recovery methods can also change over time. The value and significance of resources may have increased or decreased since previous recordings. A number of lithic procurement or prehistoric stone quarry resources, larger than can be protected by the SLT stipulations, have been identified in the last decade on the west unit of the PNG. The FS and SHPO started addressing some landscape level approaches to recording these resources but may also need to address some landscape level management approaches to minimize or remove the potential for adverse effects to these resources. Given that only around a quarter of the analysis area has been inventoried it is likely that additional larger lithic procurement resources will be identified within the analysis area.

Spatial and Temporal Context for Effects Analysis

Summary of Cultural Resources within the APE of the Current Oil and Gas Leasing Analysis

Sites were considered to be within the APE of the current analysis if they fully encompassed or exceeded a forty acre Public Land Survey System (PLSS) legal land parcel within the area proposed for a leasing decision, or could potentially be adversely affected by changes to the integrity elements of setting or feeling of the resource. Sites, smaller than a forty acre PLSS land parcel, can be protected from potential ground disturbing activities using the SLT stipulations. Sites that can be protected using the SLT, have been determined to be not eligible for the National Register of Historic Places, or are outside of the areas currently being proposed for a leasing decision have been excluded from the following summary.

Fifteen sites within the analysis area are greater than 40 acres in size and could potentially be physically impacted by the leasing decision. However an analysis of existing leases in and around the PNG administrative area indicates that all of the previous leases follow the PLSS legal land description boundaries (sections, quarter sections; quarter, quarter sections; etc.). BLM data indicates that only four leases were less than 40 acres and 49.5 % were right at 40 acres (the rest were also standard sizes: 80 acres – 22%, 160 acres -15%, 320 acres – 10%, and 640 acres – 2%). The forty acre lease size seems to be the smallest and most predominant. Four cultural resources fully

encompassed or exceeded a forty acre parcel and could not be fully protected by SLT stipulations.

For the purposes of the analysis the direct and indirect effects on the APE were determined by following the directives in 40 CFR 1508.8, 36 CFR 800.16 and the Council on Environmental Quality (CEQ), Executive Office of the President, and the Advisory Council on Historic Preservation (ACHP) Handbook for integrating NEPA and Section 106 of the National Historic Preservation Act (CEQ et. al., 2013:41).

Cultural Resources in the Direct Effects APE

Physical destruction or damage could impact these resources. Alterations to the integrity elements of materials, design, workmanship, or location could impact these resources.

Site **5WL2180** is the West Stoneham Archaeological District and management area 3.1 Special Interest Area. The site encompasses 440 acres and contains 44 documented sites representing 10,000 years of human occupation. The district includes rock shelters, stone ring camps, animal and plant processing locales, lithic quarries and lithic manufacturing sites and areas. The site is associated with Middle Paleo-Indian, Early Archaic, Middle Archaic, Late Archaic, Plains Woodland, Upper Republican, Dismal River and, Historic American Indian populations. This site is **listed** on the National Register of Historic Places. Due to the size of 5WL2180, the SLTs are not sufficient to protect it from potential adverse effects from oil and gas leasing. The 1997 Forest Plan determined that the West Stoneham SIA should be subject to the NSO supplemental stipulation for oil and gas leasing.

Site **5WL1470** is a large prehistoric open lithic and open camp site. Across the entire site area (370 acres), it is estimated that there are over 2,500 flakes and nearly 400 early stage bifaces, cores or tested raw material (TRM) are present. Four concentrations of fire affected rock were recorded within the site. A buried basin hearth was recorded in an exposed cutbank at the site. Black-stained sediments, charcoal, bone, debitage, and FCR are visible within the feature buried hearth feature. The site has yielded and is likely to yield additional information important to prehistory. Site 5WL1470 is **eligible** for the NRHP. Due to the large size of 5WL1470 the SLTs are not sufficient to protect it from potential adverse effects from oil and gas leasing. The site is considered to be within the APE of the current oil and gas leasing analysis.

Site **5WL5732** is a very large lithic procurement site and lithic scatter. The site occupies a 190 acre area. Samples of the artifacts observed at the site were recorded. The samples included 1,101 flakes and 403 cores and tested cobbles. Of the 1,101 flakes recorded, 839 were cortical flakes. Eight expedient bifacial tools and three expedient unifacial tools were recorded. The material types represented consist primarily of quartzite, chert and a very small number of chalcedony flakes. The site has yielded and is likely to yield additional information important to prehistory. Site 5WL5732 is **eligible** for the NRHP. Due to the large size of 5WL5732 the SLT are not sufficient to protect it from potential adverse effects from oil and gas leasing. The site is considered to be within the APE of the current oil and gas leasing analysis.

Site **5WL8** is a stone quarry. The site consists of an extensive scatter of lithics of varying density over the crest of a ridge overlooking the head of Howard Creek. Lithic materials are present in noticeable concentrations, are quite sparse in some areas, but are

continuous over at least 90 acres. Several thousand artifacts were noted at the site; these included cobble source material of chert and quartzite, cores, flakes, and utilized flakes. The last recorder of the site recommended that the site should be monitored, protected, and that the potential for subsurface deposits be determined. The site is **unevaluated** for the NRHP.

Cultural Resources in the Indirect Effects APE

Alterations to the integrity elements of setting, character, or feeling could impact these resources.

Site **5WL1591** is the Land Utilization Program Headquarters (LUP HQ). The site consists of a 1920s era homestead that was used as the headquarters for the Land Utilization Program from 1936 to 1941. The LUP HQ is the most intact surviving site tied to the work of the Resettlement Association (RA), Soil Conservation Service (SCS), and Farm Security Administration (FSA) in the region. The site contains several buildings and significant landscape architecture elements. The LUP HQ is associated with President Franklin Roosevelt's New Deal legislative agenda to rescue the United States from the Great Depression. The New Deal programs carried out from the LUP HQ are representative of major shifts in government policy relating to land use and agriculture. After decades of encouraging settlement of the plains and giving away land through the Homestead Acts, under the Resettlement Administration the government began to buy back land it determined unsuitable for farming. These New Deal agencies marked the beginning of much greater government involvement in agricultural practice and policy including loans, subsidies, educational programs, and controlled grazing on government lands. The site is eligible for its association with significant historical events in the areas of Conservation, Politics/ Government, and for unique landscape architecture elements. The site is **listed** on the NRHP.

Site **5WL2413** is the Main Stone Circle Site. The site consists of twenty seven stone circles ranging from 3-6 meters in diameter spread along the western edge of a bluff on a northwest – southeast trending broad ridge. The site occupies a 450m (NW-SE) x 150m (NE-SW) area. Eleven flakes and three cores were observed scattered throughout the site, material types include chalcedony, quartz and chert. Eight of the stone circle features contained fire affected rock or other evidence of a hearth being present. Two hearths unassociated with any stone circle features were observed. The site is **eligible** for the NRHP.

Site **5WL3169** is the Vim Stone Circle Site. The site consists of 45 complete stone circles, 8 additional partial stone circle features, and a several hearth features. The site is **eligible** for the NRHP. Visual impacts from a wind farm adjacent to the lands managed by the PNG have already partially diminished the integrity elements of setting, character and feeling of this resource.

Site **5WL2658** is a prehistoric site that contains 27 stone circles and a lithic scatter. The site is **eligible** for the NRHP.

Site **5WL2859** is the possible location of the May 2, 1864 Battle of Cedar Creek, the first military engagement between organized American forces and Native Americans in Colorado (Noisat 1999). The site is **eligible** for the NRHP. (This site has significant value to the Northern Arapaho and Northern Cheyenne)

Site **5WL27** is the Biggs Site an open architectural site recorded in 1964. This site has also been associated with the May 2, 1864 Battle of Cedar Creek. The site includes one stone circle, 33 pottery fragments, 11 grinding stones, 17 projectile points, 2 blades, one drill, and lithic flakes. The site dates from B.P. 1400 \pm 90 (Late Prehistoric) to 1864 (Wood, 1967, Noisat 1999).

Past, Present, and Foreseeable Activities Relevant to Cumulative Effects Analysis

There are ongoing impacts to cultural resources within and adjacent to the analysis area. Human impacts and natural processes are constantly affecting cultural resources. Activities such as hunting, dispersed recreation, agriculture, oil and gas development on adjacent lands, and grazing are on-going and may impact cultural resources by causing physical damage, increasing illegal collection and vandalism, or affecting the setting and character of cultural resources.

Cultural resources are non-renewable. The loss of archaeological resources has occurred in the past and will continue to occur in the future through both natural and human causes. The accumulated loss of individual cultural resources has the potential to limit our ability to understand broad patterns of human history as well as local historical events. Over time, fewer cultural resources would be available for study and interpretation.

Oil and gas development has the potential to directly impact cultural resources by causing physical destruction, damage, or loss of critical information about prehistoric and historic life during construction of wells, access roads, pipelines and other activities associated with oil and gas development. Oil and gas development also has the potential to impact the setting and visual landscape of cultural resources. Oil and gas development accessing federally owned mineral estates are subject to authorization and consideration of cultural resources through the NEPA and NHPA section 106 processes. Lease terms that are intended to minimize or remove potential impacts to cultural resources are applied when accessing federal oil and gas leases on Federal lands and private lands. Additional lease terms may also be applied to development of federally owned mineral estates where development takes place on federal lands. The existing impacts from oil and gas leasing accessing federal estates are restricted mostly to visual impacts to the setting cultural resources. Direct impacts are avoided or mitigated.

Privately owned mineral estates are not subject to federal authorization when development takes place on private lands. There are likely ongoing, direct, and irreversible impacts to cultural resources on private lands accessing private mineral estates. The loss of cultural resources and archaeological information diminishes the understanding of past human behavior.

Alternative 1 – No Leasing

This alternative proposes that all lands in the project area will not be available for leasing whatsoever. Stated simply, the projection is zero with no new leases issued on these lands. Lands already leased would continue under their terms—approximately 43,398 acres.

Direct Effects

Under the No Leasing Alternative there would be no direct effects to cultural resources within the analysis area.

Indirect Effects

Under the No Leasing Alternative there is potential that oil and gas development would increase on lands adjacent to the current analysis area (Federal lands previously leased, State lands, and Private lands). The potential for the increased development to be is not expected to be measurably different than the current RFD scenario. Development in the area is not expected to decrease and the logistics of avoiding federal mineral estate, no leasing is likely to increase the disturbance on adjacent lands. Since much of this development would be taking place on private surface to access private mineral estates where cultural resources will not be considered prior to development there could be significant impacts under the no leasing alternative.

Cumulative Effects

The No Leasing alternative has indirect impacts and the impacts of other projects, looting, vandalism, erosion and other factor would combine to create significant and adverse impacts to cultural resources.

Summary of Effects

The No Leasing Alternative would have no direct impacts to cultural resources on Forest Service System lands, but could have significant and adverse indirect and cumulative impacts to cultural resources.

Alternative 2 – No Action

The No Action Alternative proposes that all lands in the project available for leasing in the 1997 Forest Plan ROD would remain available for leasing—approximately 146,367 acres. Lease stipulations determined in the 1997 Forest Plan ROD would be required on any new leases. The stipulations in the 1997 Forest Plan include several areas of No Surface Operations (NSO), Timing Limitations (TL), and Standard Lease Terms. Appendix D of the 1997 Forest Plan contains a description and location of the leasing stipulations.

Design Features and Mitigation Measures

Alternative 2 includes one NSO area specifically designed to protect cultural resources from the impacts of oil and gas leasing activities.

Alternative 2 includes a number of other stipulations (Timing Limitations, Controlled Surface Use, No Surface Occupancy Areas, No Leasing Areas and Standard Leasing Terms) designed specifically for other resources that will also protect cultural resources.

Direct Effects

Under the No Action alternative there could be potential direct effects to resources that were not identified prior to the 1997 Forest Plan decision or any resource that is too large to be protected by SLTs. There are four cultural resources (SWL2180, 5WL8, 5WL1470, and 5WL5732) where the SLTs are not sufficient to reduce or remove potential significant impacts from oil and gas leasing and mineral development. These sites are larger than the standard lease size (40 acres) and moving mineral development activities 200 meters would not remove the potential for significant impacts. Oil and gas drilling, road building, installation of pipelines, and other oil and gas development activities could cause physical destruction or damage to all or part of the resources. Oil and gas development and related activities could also cause alterations to the integrity elements of materials, design, workmanship, or location.

Three of the sites (5WL1470, 5WL5732, and 5WL8) are large lithic procurement sites. These resources have large spatial extents but only small portions of the site support their eligibility. The current lease stipulations could be applied to remove potential adverse effects to these sites in consultation with SHPO.

Under Alternative 2 there is the potential for significant impacts to cultural resources.

Indirect Effects

Under the No Action alternative there is the potential for indirect effects to cultural resources. Oil and gas development activities could alter to the integrity elements of setting, character, or feeling could impact these resources. Oil and gas development could change the visual or audible setting and cause significant impacts to cultural resources.

For the purposes of this analysis cultural resources with architectural elements and areas and resources that could be important to tribes were considered for potential impacts from visual and audible alterations from oil and gas development. There is one historical cultural resource on the PNG with intact standing architecture, 5WL1591, the LUP project headquarters, this site and the area around it are used as an administrative site and were made No Leasing by decision in the 1997 Forest Plan. Since this site is protected by the No Leasing stipulation significant impacts would not occur due oil and gas leasing activities.

Three prehistoric sites that contain large concentrations of stone circles (5WL2413, 5WL3169, and 5WL2658) were identified that could be impacted by the indirect effects of oil and gas leasing activities within the analysis area.

A viewshed analysis was run in ArcGIS on all three of these resources. For 5WL2413 and 5WL2658 the SLT stipulations that allow moving leasing activities 200 meters would be able to remove the potential for indirect effects to the site. The viewshed analysis run for site 5WL3169 indicated that there could be areas where SLTs would not be sufficient to remove potential indirect visual effects; however the setting at 5WL3169 has already been heavily impacted by the a wind farm on adjacent private lands and the site does not

retain integrity of setting or feeling. 5WL3169 also would retain numerous other character defining features (information potential, integrity of design, location, materials, and workmanship) that would still support the eligibility of the resource.

Two sites (5WL2859 and 5WL27) in the Indian Caves area have been associated with the May 2, 1864 Battle of Cedar Creek, the first military engagement between organized American forces and Native Americans in Colorado. Sites 5WL2859 and 5WL27 are within areas identified as NSO due to recreation and scenery objective concerns. These two resources would not be indirectly affected by potential indirect effects of oil and gas leasing.

Cumulative Effects

Under the No Action Alternative there is potential for cumulative effects to cultural resources. Under the No Action alternative the current analysis identified the potential for direct effects to sites 5WL8, 5WL1470, and 5WL5732 and the potential for indirect effects at 5WL3169. The potential direct effects to 5WL8, 5WL1470, and 5WL5732 combined with other ongoing human and natural impacts could create a significant and irretrievable loss of archaeological information, and damage the character defining features and integrity of cultural resources. The accumulated loss of individual cultural resources has the potential to limit our ability to understand broad patterns of human history as well as local historical events.

Under alternative 2 there is the potential for significant cumulative effects to cultural resources.

Alternative 3 – Leasing under No Surface Occupancy (NSO)

Leasing under NSO proposes that all lands in the project area determined as administratively available for leasing under the 1997 ROD would continue to be available for leasing—approximately 146,367 acres. On these lands the Forest Service would require a No Surface Occupancy stipulation. The NSO stipulation would prohibit occupancy and use of the surface for oil and gas operations. The projection for these lands would be zero because no wells or well pads would be allowed. Although the NSO stipulations would be applied to these lands, the NSO stipulation does not prohibit oil and gas from being leased in these areas. If these lands were leased with an NSO stipulation, oil and gas could be extracted by locating facilities on non-NFS lands and horizontally drilling underneath the surface.

Design Features and Mitigation Measures

A supplemental NSO stipulation would be added to Alternative 3 for protection of resources on the entire analysis area.

Direct Effects

Under Alternative 3 the design features of the alternative could remove any significant direct effects to historic properties within the analysis area. The entire analysis area would be protected from ground disturbing activities. The potential for destruction or damage to all or part of the historic properties within the Analysis area would be removed by removing oil and gas development activities from the analysis area.

The design features of Alternative 3 would protect cultural resources from direct effects. There would not be any significant direct impacts to cultural resources under Alternative 3.

Indirect Effects

The RFD scenario would still apply and development would be expected to occur on the private lands adjacent to the project area. There could be increased development on lands adjacent to the PNG to access the oil and gas leased under the federal surface through horizontal drilling. However the Bureau of Land Management (BLM) is also required to take cultural resources into consideration through the NEPA and Section 106 process when oil and gas development proposals are considered on private lands to access federal mineral resources (BLM 2008).

Since the BLM would be required by NEPA and the NHPA section 106 process to consider the effects to cultural resources there would not be any significant indirect impacts to cultural resources under alternative 3.

Cumulative Effects

Alternative 3 would have no direct or indirect effects and that could combine with past, present, or reasonably foreseeable future actions to create cumulative effects.

Summary of Effects

Through the consideration of effects to cultural resources in the current analysis the Forest Service feels the following findings of effect are appropriate:

Alternative 1: The Forest Service feels a finding of *significant impacts to cultural resources* is appropriate for Alternative 1. The analysis of the no leasing alternative identified potential significant indirect and cumulative impacts to cultural resources.

Alternative 2: The Forest Service feels a finding of *significant impacts to cultural resources* is appropriate for alternative 2. Potential direct effects were identified for 5WL1470, 5WL5732, and 5WL8 and potential indirect effects were identified for 5WL3169.

Alternative 3: The Forest Service feels a finding of *no significant impacts to cultural resources* is appropriate for alternative 3. No direct, indirect, or cumulative effects were identified in the Analysis for the NSO alternative. All of the resources considered in this analysis would be protected from ground disturbing activities under the NSO stipulation. The BLM is also required to take cultural resources into consideration through the NEPA and Section 106 process when oil and gas development proposals are considered on private lands to access federal mineral resources (BLM 2008).

Table 66: Summary of Potential Impacts to Previously Recorded Cultural Resources by Alternative

Resource Component	Alternative 1: No Leasing	Alternative 2: No Action	Alternative 3: NSO
5WL2180	No Impacts	No Impacts	No Impacts
5WL1470	No Impacts	Direct Impacts	No Impacts
5WL5732	No Impacts	Direct Impacts	No Impacts
5WL8	No Impacts	Direct Impacts	No Impacts
5WL1591	No Impacts	No Impacts	No Impacts
5WL2413	No Impacts	No Impacts	No Impacts
5WL3169	No Impacts	Indirect Impacts	No Impacts
5WL2859	No Impacts	No Impacts	No Impacts
5WL27	No Impacts	No Impacts	No Impacts

3.15 Transportation

3.15.1 Affected Environment

Potential future leasing and development could result in changes to the Pawnee National Grasslands transportation system by increasing the miles of new road constructed and by increasing the volume of traffic traveling on existing and/or proposed routes.

Existing Roads

The following tables are the mileages of existing National Forest System Roads (NFSR's) and of Non-Forest Service Jurisdiction Roads within the Pawnee Ranger District (as of February 28, 2014, taken from Infra). Infra information within this report was based on the information contained in this system at the time of the analysis. Although the best information at the time of this study, it is approximate and may change. Mileages in Tables 1 and 2 include roads within the entire Pawnee National Grasslands (not just the project area, or acres available for leasing).

Table 67 Miles of Forest Service Roads on the Pawnee National Grasslands

	Miles Forest Service Jurisdiction and/or FS System		
Operational Maintenance Level	Open only to Admin.	Open to Public	Total Existing
1*	N/A	N/A	11.0
2	427.9	123.0	550.9
3	16.0	52.9	68.9
4	0.1	3.1	3.2
5	0	0	0
Total PRD FS Miles	444.0	179.0	634.0

Table 68 Miles of road that are non-Forest Service jurisdiction or non-NFSR roads on the Pawnee National Grasslands**

Non- Forest Service Jurisdiction	Miles of Road
County	786.4
Other Federal	0.6
Private	57.9
State	143.1
Total PRD Non-FS Miles	988.0
Total PRD Unauthorized Miles	100.1

* ML 1 roads are closed roads that are not open to any travel.

** The Forest Service only captures miles of roads that serve to connect the public to Forest Service property and roads. Therefore, miles of "Non-FS Jurisdiction" and "Unauthorized" are only those miles that are either intermingled with FS miles or that link the public to FS miles and are captured/recorded in IWeb/Infra. These numbers are not an accurate count of all miles within the Forest boundary.

As seen in the table above, most NFSR's on the Pawnee National Grassland are roads open for use by high clearance vehicles (Maintenance Level 2). Most passenger vehicle roads are Weld County jurisdiction.

A Motor Vehicle Use Map (MVUM) was published for the Pawnee National Grasslands and is revised as necessary. This map contains the existing direction for motor vehicle use open to the public on the district. Motor vehicle use (excluding snowmobiles operating on snow) is allowed on designated roads and trails shown on the MVUM. The MVUM's for the ARP, are available on the web (under "Maps and Publications") at: <http://www.fs.usda.gov/main/arp/home>

Existing Traffic

As mentioned in the table above, most NFSR's on the Pawnee National Grassland are roads open for use by high clearance vehicles. Most passenger vehicle roads are Weld County jurisdiction. Information on County roads and traffic studies can be found on the Weld County website and include the following links:

<http://www.co.weld.co.us/Departments/PublicWorks/TrafficandSigning.html>

<http://www.co.weld.co.us/assets/064C3b1c7b7bB7bDb67D.pdf>

<http://www.co.weld.co.us/assets/1DCAc997314Dd41dD1c5.pdf>

The Arapaho and Roosevelt National Forests and Pawnee National Grasslands does not have existing traffic data.

Management Direction

General Forest Plan Direction

The Forest Plan provides guidance to minimize the impacts of roads and trails on natural resources such as soil, water, and wildlife. The following are some of the guidance found in the Forest Plan (and which chapter it is located) related to roads:

- Based on site-specific environmental decisions, all “ways” will either be reclassified as FDRs or FDTs (Forest Development Roads and Forest Development Trails) or will be scheduled for obliteration (*Introduction – Travel Management*).
- Provide an integrated travel system that considers various modes of motorized and nonmotorized use consistent with the resource capacity of the area (*Chapter 1 – Human Uses*).
- Limit roads and other disturbed sites to the minimum feasible number, width, and total length consistent with the purpose of specific operations, local topography, and climate (*Chapter 1 – Erosion and Sediment*).
- Construct roads and other disturbed sites to minimize sediment discharge into streams, lakes, and wetlands (*Chapter 1 – Erosion and Sediment*).
- Stabilize and maintain roads, trails, and disturbed sites during and after construction to control erosion (*Chapter 1 – Erosion and Sediment*).
- Reclaim roads and other disturbed sites when use ends, as needed, to prevent resource damage (*Chapter 1 – Erosion and Sediment*).
- System travelways determined to be no longer needed to achieve proposed management activities or located where resource damage cannot be mitigated shall be obliterated, revegetated, and sloped to drain (*Chapter 1 – Infrastructure*).
- Maintain all roads at the minimum maintenance level to meet the management objectives for the area (*Chapter 1 – Infrastructure*).
- Manage road use by season restriction if its use causes unacceptable damage to soil and water resources due to weather or seasonal conditions (*Chapter 1 – Infrastructure*).
- Decisions about which roads and trails to keep open or to close will be implemented under formalized travel management plans (*Chapter 2 – Travel Management Strategy*).

Management Area Direction

The 1997 Revision of the Land and Resource Management Plan for the Arapaho and Roosevelt National Forests and Pawnee National Grassland establishes programmatic direction for the management of National Forest System lands.

The Arapaho and Roosevelt National Forests are broken into discrete Management Areas. Management Areas provide management direction by emphasizing a particular resource and identifying associated guidelines (prescriptions) for management activities. The following management areas are located in the analysis area: 2.2, 3.1 (Owl, W. Stoneham, Keota, and Buttes), 3.61, 4.2, 4.3 (Main and Coal), 6.4, 6.6, and 8.21. Excerpts regarding roads and/or travel management are summarized below.

Table 69 Management Area Summary

Management Area 2.2 (Research Natural Areas)	<p>Research Natural Areas (RNAs) form a long-term network of ecological reserves designated for nonmanipulative research, education, and the maintenance of biodiversity.</p> <ul style="list-style-type: none"> • Prohibit motorized use, except when necessary to provide research, administrative, or educational access. • Prohibit the construction of new roads. • Prohibit motorized and mechanized use, except when they provide necessary access for scientific, administrative, or educational purposes. • Close or obliterate existing roads, except where they provide necessary access for scientific, administrative, or educational purposes.
Management Area 3.1 (Special Interest Areas) – Owl, W. Stoneham, Keota, Buttes	Management emphasis is on public education, interpretation, recreation or development while protecting or enhancing areas with unusual characteristics.
Management Area 3.61 (Prairie Woodlands)	Management emphasis is to maintain or enhance woody vegetation.
Management Area 4.2 (Scenic Areas)	<p>Management emphasis is to protect or preserve scenic values and recreational uses of designated scenic byways and other heavily used scenic travel corridors.</p> <ul style="list-style-type: none"> • Provide a variety of motorized and nonmotorized recreational opportunities. • Provide access to natural attractions, water features, or areas that provide desired recreational opportunities. • Improvements such as improved roads, primitive roads, trails, bridges, fences, shelters, overlooks, signs, or water diversions will bend into the landscape where feasible, be removed if no longer needed, or will be designed to be minimally intrusive into the landscape.
Management Area 4.3 (Dispersed Recreation) – Main, Coal	<p>Management emphasis is to provide recreational opportunities in natural or nearly natural-appearing landscapes.</p> <ul style="list-style-type: none"> • Blend existing improvements such as improved roads, primitive roads, trails, bridges, fences, shelters, signs or water diversions into the landscape where feasible or remove them if no longer needed. • A wide spectrum of travelways exist, from primary highways to primitive roads and trails that serve as recreational features themselves. Travelway densities may remain fairly constant. Open roads provide motorized recreational opportunities and restricted roads provide nonmotorized opportunities. Provide access to natural attractions, water features, and other areas that provide desired recreational opportunities
Management Area 6.4 (Mid-Composition – High Structure: Native Shortgrass Prairie Ecosystem)	<p>Management emphasis is on providing representative native shortgrass prairie ecosystems as habitat for associated plant and animal species.</p> <ul style="list-style-type: none"> • Roads are primitive two-track with occasional improved ditched and crowned roads.
Management Area 6.6 (L-Composition –Low Structure: Grassland Resource Production)	<p>Lands classified for grassland resource production are managed to provide healthy and sustainable plant communities dominated by herbaceous and grass species</p> <ul style="list-style-type: none"> • Roads are primitive two-track with occasional improved ditched and crowned roads.
Management Area 8.21 (Developed Recreation Complexes)	<p>Management emphasis is to provide a variety of recreational opportunities in highly developed, multiple-site recreational complexes.</p> <ul style="list-style-type: none"> • Provide access to and parking for sites, natural attractions, water features, or areas that provide desired recreational opportunities such as camping,

	hiking, bicycling, winter use, fishing, and scenic driving. • Roads and recreational sites may be paved.
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3.12.3 Environmental Consequences

Transportation for this section of analysis is defined as the network of National Forest System (NFS) roads within the project area. The project area for the Pawnee National Grassland Oil and Gas EIS includes all lands identified in the 1997 Forest Plan as administratively available for leasing. However, for the transportation analysis, “project area” and “Pawnee National Grasslands” in its entirety are used interchangeably since the transportation effects analysis estimates road construction and traffic increases based on estimated well pad construction and not specific location.

This section addresses potential impacts to the Forest Service transportation system that could occur under a new leasing decision. Potential impacts for this transportation analysis are derived from the *Reasonably Foreseeable Development Scenario for Oil and Gas Royal Gorge Field Office, Colorado (March 22, 2012) Final Report*.

Making lands available for oil and gas leasing and the subsequent leasing of available lands does not involve any direct effects to the transportation system. However, potential future leasing and development could result in changes to the Pawnee National Grasslands transportation system by increasing the miles of new road constructed and by increasing the volume of traffic traveling on existing routes. For future development proposals, travel management and access would be discussed at the site-specific environmental analysis phase. The location of well pads and roads will not be determined as a result of the leasing revision, but will be fully discussed at the project level of analysis. The existing policy and regulatory framework within the Forest Service requires and ensures proper planning, design, approvals, construction, maintenance, decommissioning and monitoring of any new roads or changes to the existing transportation system.

Estimated New Road Construction

The estimate of miles of new road due to potential future development of oil and gas leases were calculated using the estimates listed in the *Reasonably Foreseeable Development Scenario for Oil and Gas Royal Gorge Field Office, Colorado (March 22, 2012) Final Report*, referred herein as the RFDS.

According to the RFDS, oil and gas well pads with one, two, three or four wells will have an initial disturbance of 0.91 acres associated with the road. For coalbed natural gas well pads, the initial road disturbance is 1.35 acres. This does not include any roads associated with pipelines, if needed.

Typically roads will be 20-30 feet wide with ditches, which for 0.91 acres would equate to road length of 0.25-0.38 miles. The worst case assumption of 0.38 miles per well pad will be used. Assuming that a coalbed natural gas well pad would not need to be longer

than an oil and gas well pad, just wider, a 30' foot wide road would equate to a length of 0.37 miles. Since the estimated road lengths are similar for all well pad types (oil and gas and coalbed natural gas), it is assumed for this analysis that the average well pad road length is 0.38 miles for all types of well pads.

Estimated Oil and Gas Traffic

Several sources were referenced in determining the expected increase in traffic due to oil and gas development and production. The most recent and comprehensive was the Final Draft of the *Boulder County Oil and Gas Roadway Impact Study* dated January 14, 2013 by Feldburg Holt & Ullevig. With the heightened interest in future oil and gas activity in and around Boulder County (located southwest of Weld County), the County issued a moratorium on drilling in February 2012. Since then, the County has worked to research and characterize many facets of oil and gas land use. This study is part of the broader update of the proposed oil and gas land use regulations. The study sought to understand the potential impacts of oil and gas development to the county roadway system and to design fees as a prospective method to recover incremental costs associated with road deterioration and safety. The details in the increased traffic estimates can be found in the *Boulder County Oil and Gas Roadway Impact Study* which is located at the following Boulder County website address:

<https://www.bouldercounty.org/dept/landuse/pages/oilgas.aspx>

Estimates for Oil and Gas Traffic referenced from other studies and are summarized in the table below. There does not appear to be a uniform method of displaying traffic volumes by stage or phase. Some estimates appear to include exploratory estimates, some include abandonment estimates, and some appear include neither.

Table 70 Estimates of traffic from oil and gas development and production.

Source	Exploration and/or Construction, Drilling, Completion		Production	
	Trips	Duration	One-Way trip	Duration
<i>Boulder County Oil and Gas Roadway Impact Study, 2013</i> 1well per well pad	See Note 1 2,206 total trips @ 36 total trips/ day Converted this is 4,412 one-way trips @ 72 one-way trips /day	2 months	See Note 2 730 trips annually, based on 2 trips/day Converted this is 1 two-way trip/day	Life of the well
<i>Boulder County Oil and Gas Roadway Impact Study, 2013</i> 4 wells per well pad Ref: Tables 8 and 9, pages 36 and 37	See Note 1 7,230 one-way trips over @ 40.2 one-way truck trips/ day	180 days	See Note 2 730 trips annually, based on 2 trips/day Converted this is 1 two-way trip/day	Life of the well
<i>Oil and Gas Leasing on Lands Administered by the Dixie National Forest Final Environmental Impact Statement, August 2011</i> Section 4.10, pages 4-172 and 4-173, Appendix E	See Note 3 1,924 one-way trips @ 16 one-way trips/ day per exploration well (this would calculate as 1,824 one-way trips without the well plugging and abandonment) See Note 5 Development of a 20 well field 6,884 trips. 13 one-way trips/day for 20 wells	120 days 520 working days	See Note 4 15 trips/ day (note: this is per field, text reports one-way but Appendix E reports roundtrip)	
<i>White River Oil and Gas Leasing DEIS, August 2012</i> Sections 3.4.10, Pages 3-324 and 3-325	See Note 6 For the development phase, up to 50 roundtrips per day, or 100 one-way trips per day Operations on a 7 well pad could take up to a full year before the well was fully productive.			

Note 1: Includes Pad and Road Construction, Drilling, and Completion

Note 2: Includes Oil & Water Removal and Operation and Maintenance

Note 3: Includes Area Reconnaissance and Surveying, Mobilization of Construction Equipment, Road and Pad Construction, Drill Rig Mobilization, Exploration Drilling, and Well Plugging and Abandonment/Reclamation of Pad and Road (No Discovery)

Note 4: Includes hauling oil to market /refinery, dispose of water/distillates/gas, workover rigs, maintenance/repairs, personnel/supplies

Note 5: This number was taken from text on page 4-173 and is unclear what production items it includes from the Fishlake EIS traffic estimate

Note 6: Includes construction, drilling, completion, production, and reclamation

3.16 Economics

Introduction

The Pawnee National Grassland (PNG) is the United States' last remaining short grass prairie. Located in the Eastern Plains of northern Colorado, these grasslands are situated in a 30-by-60 area of the South Platte River which stretches 90 miles northeast of Denver all the way to southeastern Wyoming and southwestern Nebraska borders. Managed by the Arapahoe and Roosevelt National Forests, the PNG includes two parcels totaling 193,060 acres of land in Weld County. This area is characterized as having a checkered land ownership pattern, where private lands are intermixed with State of Colorado, Forest Service and Agricultural Research Service lands.

Although developed facilities are limited on the grassland, recreation opportunities are not. Recreationists are attracted to the Pawnee's horseback and hiking trails, the scenic byways used for wildlife viewing and stargazing, and its open spaces used for dispersed camping and picnicking. These grasslands also provide habitat for many high plains species including the mountain plover, burrowing owl, pronghorn, mule deer, coyote, swift fox, snakes, and prairie dogs; and is an important stop for migratory birds along the Central Flyway. Management of the PNG balances these recreational and wildlife uses with consumptive uses that include livestock grazing and oil and gas development.

As of January 17, 2013 there were 199 plugged and abandoned wells and 62 wells producing oil and gas on the Pawnee. While current oil and gas development on the PNG is commensurate with the 1997 Forest Plan, sharp increases in Applications for Permits to Drill (APD's) have indicated that Niobrara, which includes the PNG, is entering a development boom. Recent estimates have projected that up to 800 wells could be established in the Niobrara over the next 10 to 15 years. In order to protect resources and mitigate adverse effects of future oil and gas development, forest management will reevaluate and update lease stipulations on lands identified as administratively available for leasing, but are not currently leased. This report provides social and economic analysis in support of the Supplemental Environmental Impact Statement (EIS) for the oil and gas development on the Pawnee National Grasslands.

3.16.1 Affected Environment

Located 35 miles east of the Forest Supervisors' Office in Fort Collins and 25 miles northeast of the District office in Greeley, the PNG includes the communities of Keota and Purcell and the town of Grover is located directly between Pawnee's two parcels near Crow Creek. While few people live within the boundaries of the Pawnee planning area, numerous nearby communities have longstanding social and economic ties to the natural and cultural resources of the Pawnee. Since neighboring communities may be affected by forest management decisions on the PNG, it

is important to examine existing socioeconomic conditions of a broader region in order to establish a baseline which these potential impacts can be measured against.

To more effectively examine the linkages between Forest Service lands and the local communities they serve, the geographic scope of this analysis has been expanded beyond PNG boundaries to encompass a study area which includes all of Larimer, Logan, and Weld Counties. The following Affected Environment section will analyze trends and current conditions related to the social and economic environment of the planning area, including: population and demographic changes, potential environmental justice populations, and employment and income conditions. To address large scale impacts without masking changes in smaller regions, this analysis will use a multidimensional approach to analysis trends at the state, aggregated three-county study area, and individual county levels.

Population and Demographics

This section highlights population and demographic trends in the study area. Population is an important consideration in managing natural resources. In particular, population structure (size, composition, density, etc.) and population dynamics (how the structure changes over time) are essential to describing the consequences of forest management on the social environment (Seesholtz et al. 2004).

Population Growth

This section highlights population and demographic trends in the study area. Population is an important consideration in managing natural resources. In particular, population structure (size, composition, density, etc.) and population dynamics (how the structure changes over time) are essential to describing the consequences of forest management on the social environment (Seesholtz et al. 2004).

Population Growth

Population growth can be an indicator of a region's desirability to live and work. As displayed in Table 71, rapid population growth in Colorado over the last thirty years suggests the state is a highly desirable for current and prospective residents. While the total U.S. population grew by 36 percent between 1980 and 2010, the state's population increased by 74 percent. While Colorado is known for its mountainous terrain, two fifths of the state's land is on the eastern slope where the Rocky Mountains meet the Great Plains. In 2010 82 percent of Colorado's population lived along the eastern slope of the Rockies in a region known as the Front Range. The North Front Range, which includes Larimer and Weld Counties, housed 10 percent of the state's population in 2010 and has supported a large share of growth in recent years (U.S. Census, 2010).

On annual average, Larimer and Weld Counties have grown by 3 percent over the last thirty years, causing populations to more than double in these two counties. Though growth in Larimer County has slowed, falling from a high of 35 percent in the 1990's to 19 percent in the early 2000's; Weld County has continued to grow at an increasing rate. Weld's population increased by 37 percent in the 1990's and by another 40 percent between 2000 and 2010, making it Colorado's second fastest growing county. Population centers within these counties include Fort Collins, the county seat of Larimer County, and Greeley, the county seat of Weld County. In 2010 these cities had a population of 143,986 and 92,889 respectively (U.S. Census, 2010).

Growth in neighboring Logan County has occurred much slower than the other counties included in the study area, with 15 percent growth over the last three decades. In the late 1980's Logan experienced an 11 percent population decline, quickly rebounding and growing by 15 percent in the 1990's and by another 11 percent over the first decade of 2000. More than half Logan County's population lived in the county seat of Sterling in 2010, with 14,777 city residents (U.S. Census, 2010).

Table 71 Population Totals: Current and Historic

	1980	1990	2000	2010	Percent Change (1980-2010)
United States	226,545,805	248,709,873	281,421,906	308,745,538	36%
Colorado	2,889,964	3,294,394	4,301,261	5,029,196	74%
3 County Area	292,422	335,524	452,934	575,164	97%
Larimer County	149,184	186,136	251,494	299,630	101%
Logan County	19,800	17,567	20,504	22,709	15%
Weld County	123,438	131,821	180,936	252,825	105%

Source: U.S. Census Bureau, 1990, 2000, 2010

As shown in Table 72, population growth in the United States is anticipated to continue over the coming years. Between 2010 and 2030 Colorado and the three-county study area are forecasted to grow at a much faster rate than the general U.S. population. Though Larimer and Logan counties are expected to experience considerable growth, the population of Weld County is anticipated to increase by 76 percent (Colorado State Demography Office, 2013)

Table 72 Population Projections 2015-2030

	2015	2020	2025	2030	Growth Between 2010 and 2030
United States	321,363,000	333,896,000	346,407,000	358,471,000	16%
Colorado	5,438,077	5,915,922	6,413,554	6,888,181	37%
3 County Area	633,736	713,655	805,778	898,120	56%
Larimer County	328,236	360,813	394,236	424,833	42%
Logan County	22,794	24,253	26,147	28,127	24%
Weld County	282,706	328,588	385,394	445,160	76%

Source: U.S. Census Bureau 2012, Colorado State Demography Office, 2013

Changes in a region's population can be attributed in part to natural increase (births minus deaths) and in part to net migration, which may affect the availability of housing, services, and jobs. Over the thirty years between 1980 and 2010, growth in Colorado was equally attributed to migration and natural causes. Growth in the study area over this time period however was clearly driven by migration, accounting for more than half of total population in the Larimer, Weld, and the three-county study area. While natural causes accounted for the majority of population change in Logan County (87%) over the last thirty years (Colorado State Demography Office, 2013).

Amenities or the natural, cultural, and social characteristics of an area have played an increasing role in U.S. migration and growth along Colorado's Front Range. Areas characterized as having high levels of natural amenities have been shown to experience greater population growth than areas with fewer natural amenities (Rudzitis and Johansen 1991, Johnson and Beale 1994, Beale and Johnson 1998, McGranahan 1999, Hunter et. al 1999, Frentz et. al 2004), and that this growth was occurring increasingly at the boundaries of public lands (Hansen et. al 1998, Radeloff et. al 2001). In recent years counties like Larimer and Weld have become increasingly attractive to many Americans not only because they support a wide range of employment and education opportunities, but because their proximity to open spaces and natural settings provide residents with easy access to recreational opportunities year round. As a steward of Northern Colorado's public lands, a portion of population growth in this region can be attributed to the scenic beauty and outdoor recreation supported by the PNG.

Table 73 Components of Population Change between 1980 and 2010

	Births	Deaths	Net Migration	Percent Change from Natural Causes
Colorado	1,837,924	756,902	1,102,358	50%
3 County Area	186,726	76,250	179,494	38%
Larimer County	91,582	39,865	101,953	34%
Logan County	8,190	5,548	401	87%
Weld County	86,954	31,367	78,400	88%

Source: Colorado State Demography Office, 2013

Future population projections indicate that migration will play an increasing role in Colorado's growing population, and is forecasted to account for nearly 58 percent of the state's population change between 2010 and 2030. Over this time period net migration is expected to account for 71 percent of total population change within PNG's larger study area; and 76, 67, and 68 percent of the change in Larimer, Logan, and Weld counties respectively (Colorado State Demography Office, 2013).

Population Density

Population density measures the number of people living per square mile within a given area. This measure can serve as a valuable indicator of the socioeconomic and living conditions of a region, including: urbanization, availability of open space, socioeconomic diversity, and civic infrastructure (Horne and Haynes 1999). In general, more densely populated areas tend to be more urban, diverse, and offer better access to infrastructure. In contrast, less densely populated areas provide more open space, which may offer natural amenity values to residents and visitors. Table 74 displays the number of people per square mile at the county, state, and national levels (U.S. Census Bureau 2010).

Although Colorado has experienced substantial population growth over the last thirty years, the state continues to be much less densely populated than the nation as a whole. Logan was the most rural of the three counties in the study area with fewer people per square mile than the state and the nation. Although Weld had a higher population density than state of Colorado, it is less dense than the nation. Larimer County was the most densely populated county in the study area with a population density greater than the state and nation. Comparing population densities from 2000 to those from 2010 show that all three counties in the study area became more densely populated, with the greatest increases in people per square mile occurring in Larimer (+ 18.5 people) and Weld (+ 18 people) Counties (U.S. Census Bureau 2000,2010). With forecasts showing continued growth along Colorado’s Front Range, it is certain that population densities at the state and county level will rise over the coming years.

Table 74 People per Square Mile

	2000	2010
United States	79.7	87.4
Colorado	41.5	48.5
Larimer County	96.9	115.4
Logan County	11.2	12.4
Weld County	45.4	63.4

Source: U.S. Census Bureau, 2000, 2010

Age and Gender

A population’s age may affect community values and uses associated with Forest lands, making it relevant to Forest management decisions. In 2010 the median age in the United States was estimated to be 37.2 and 36.1 in Colorado. While Colorado’s population tends to be slightly younger than the general U.S. population, residents of Logan are slightly older with a median age of 38.4. Larimer and Weld counties are young relative to the state and the nation, with median ages of 35.5 and 33.1, respectively (U.S. Census Bureau 2010). The relatively young and diverse populations in these counties can be attributed to Colorado State University in Fort Collins and University of Northern Colorado in Greeley. Roughly half of the population in these counties is below the age of 35, with high concentrations of twenty-somethings living in the college town of Fort Collins (median age 30.4) and Greeley (median age 30.3) (U.S. Census Bureau 2010).

Gender distribution is another important indicator of socioeconomic conditions. Numerous factors may skew the distribution of males and females in region, including cultural gender preferences and natural birth and mortality rates. Other social and economic factors such as (1) the significant presence of an industry that is often dominated by one gender – e.g., forestry or oil and gas exploration and development; (2) a large number of single-parent households; and (3) a combination of the above and other unnamed factors may also cause populations to have uneven distributions of males and females.

Table 75 breaks down national, state, and county populations into shares of males and females. Sex ratios in the U.S. and the PNG three-county study area were relatively equal in 2010, with a slightly disproportionate male population in Logan County. Although recent reports indicate there is a proportionate ratio of males to females in the study, further oil and gas development on the PNG may skew future sex distributions as the male dominated oil and gas industry expands. While the long term consequences of disproportionately male populations in the United States have not been documented, numerous studies have examined the effects on Asian populations where sex ratios have been skewed for generations. These studies have found that prolonged gender disparities have an adverse effect on birth rates (Miller 1981, Caldwell 2001), lead to increases in violent and low skill crime (Smil 2005, Hesketh & Xing 2006, Edlund et al.2009), and puts individuals at greater risk for sexually-transmitted infections (Tucker et al. 2005).

Table 75 Gender Distribution: Percent of Total Population

	Male	Female
United States	49.2	50.8
Colorado	50.1	49.9
Larimer County	49.6	50.4
Logan County	56.9	43.1
Weld County	50.0	50.0

Source: U.S. Census Bureau 2010, Table DP-1

Racial and Ethnic Composition

Colorado's predominately white population is less diverse than the general U.S. population, with nearly 81 percent of its residents identifying themselves as white alone. While the state was reported to have disproportionately small populations of African Americans, Asians, and Native Hawaiian/ Pacific Islanders relative to the general population, Colorado had larger shares of residents identifying themselves as American Indian, Two or more races, or some other race. 2010 census data also indicated that the three-county region was less diverse than general state and national populations, with even larger shares of their populations identifying themselves as white alone. While Larimer (90.5%), Logan (89%), and Weld (82.9%) are all predominately white, Larimer was reported to be the least racially diverse of the three. Minority groups as a share of Larimer County's total population was lower than their shares of the general population

at the state and national level, although Native Hawaiians and other Pacific Islanders were equally represented at the state and county level. Logan County also had a high concentration of residents identifying themselves as white alone, but its populations of African American and Native Hawaiian/ Pacific Islander were proportionate to those of Colorado's general population and its American Indian population accounted for a slightly greater share of the population (Table 6) (U.S. Census Bureau, 2010).

Many Americans identify with racial groups based on physical attributes but continue to be proud of the cultural heritage from which they descend. Although Americans may appear to look White, Black, Asian, or belonging to some other racial group, they often continue to speak the native language and follow cultural traditions from the regions where their families originated. This is especially common among Americans of Hispanic, Latin, or Spanish descent. In 2010 roughly 17 percent of the U.S. population and 22 percent Colorado's population described their family ancestry as being Hispanic, Latin, or Spanish. These cultures also have a noticeable presence in the PNG study area as well, with 11.5, 16.3 and 30 percent of three counties respectively reporting that they have a Hispanic origin (Table 76) (U.S. Census Bureau, 2010).

Table 76 Racial and Ethnic Composition

	White	African American	American Indian	Asian	Hawaiian/ Pacific Islander	≥ 2 Races	Other	Hispanic Origin
United States	72.4 %	12.6%	0.9%	4.8%	0.2%	2.9%	6.2%	17.4%
Colorado	81.3 %	4.0%	1.1%	2.8%	0.1%	3.5%	7.2%	22.2%
Larimer County	90.5 %	0.8%	0.7%	1.9%	0.1%	2.8%	3.2%	11.5%
Logan County	89.0 %	4.0%	1.2%	0.6%	0.1%	1.4%	3.7%	16.3%
Weld County	82.9 %	1.0%	1.1%	1.2%	0.1%	2.9%	10.8%	30.0%

Source: U.S. Census Bureau, 2010: Table QT-P6

Educational Attainment

Educational attainment measures the number of people within a region who have earned a high school diploma or bachelor's degree. Levels of education can be an important indicator of the social and economic opportunities and ability of an area to adapt to change. Table 77 lists the percentage of the adult population with at least a high school diploma and a bachelor's degree.

Table 77 Educational Attainment, Percent of Persons Age 25+

	High School Diploma +	Bachelor's Degree +
United States	85.4%	28.2%
Colorado	89.7%	36.3%
Larimer County	93.9%	43.1%
Logan County	87.5%	16.4%
Weld County	85.2%	25.6%

Source: U.S. Census Bureau, 2010

Colorado in general has a fairly well educated population, with the vast majority of adult residents obtaining at least a high school level education. While roughly 85 percent of the U.S. population holds a high school diploma, nearly 90 percent of Colorado residents and 94 percent of Larimer County residents have completed high school. The study area also has a large share of residents who have pursued higher education and have obtained a bachelor's degree or higher. Although Larimer and Weld counties are both centers for higher education, Larimer County appears to have more success attracting and retaining working-age adults with high levels of education. With roughly 43 percent of its residents possessing a bachelor's degree or higher, it is likely that Larimer County offers a greater number of opportunities for highly educated workers than Weld County. The presence of so many highly educated adults may be self-reinforcing as a highly educated population tends to be a signal that an area provides economic and cultural opportunities, attracting additional college educated adults to the area. This process leads to further economic development and job creation. In contrast, areas with low levels of educational attainment tend to have lower levels of human capital, which reduce the area's ability to capitalize on economic change (Florida 2002).

Although the planning area contains several post-secondary institutions (including two four year universities and a community college) and a growing number of residents have access to distance learning programs, educational attainment within Logan County remains low relative to the nation, state, and other counties in the study area. Logan County likely suffers from what is known as "brain drain"- where the youth of a community migrates out to further their education and often take up residency in areas with greater employment opportunities upon completing their studies.

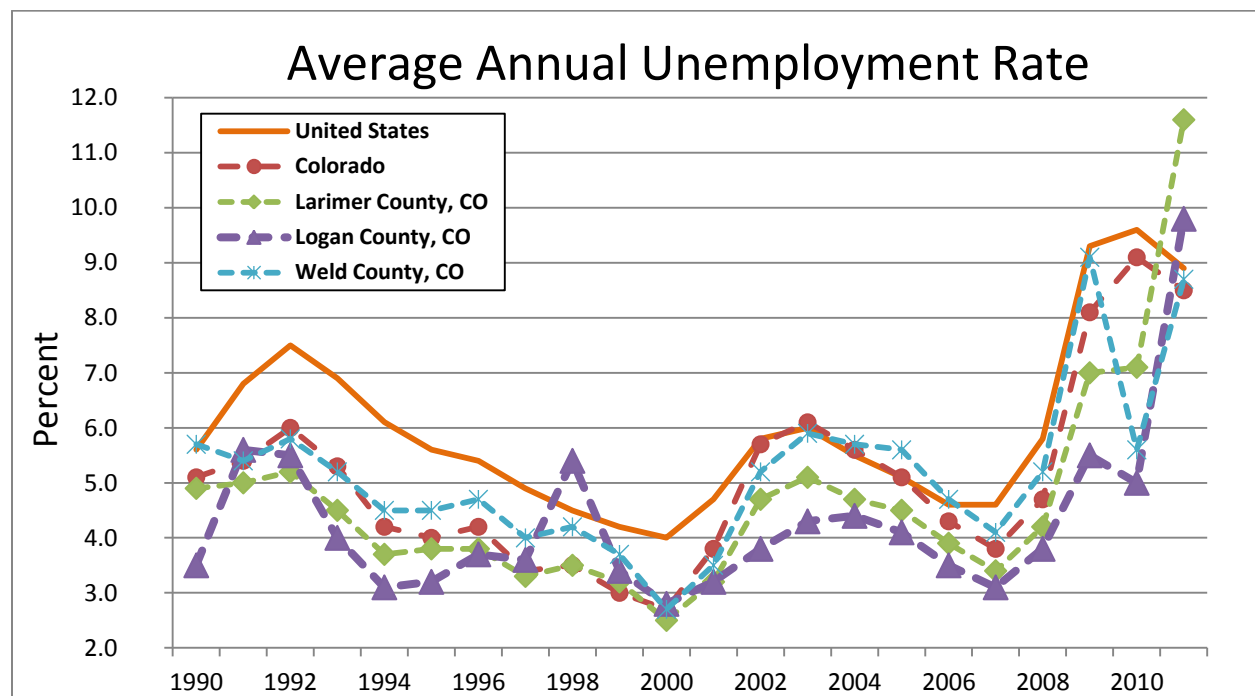
Employment, Income, and Housing

The previous section discussed demographics and population trends in counties surrounding the Pawnee National Grasslands relative to the state and national statistics. The following section will focus on economic conditions within the study area to further develop a baseline upon subsequent impact analyses can be compared.

Unemployment

The unemployment rate provides insight into the correspondence between residents' skills and employment opportunities. The "natural" rate of unemployment is said to be around 5 percent. This is the so-called "natural" rate because this is a level that allows for movement between jobs and industries, but does not signal broad economic distress. Recently, the national unemployment rate has hovered between 8 and 10 percent. Figure 38 provides the annual unemployment rates for the counties, state, and nation from 1990 to 2011.

Figure 65 Unemployment 1990-2011



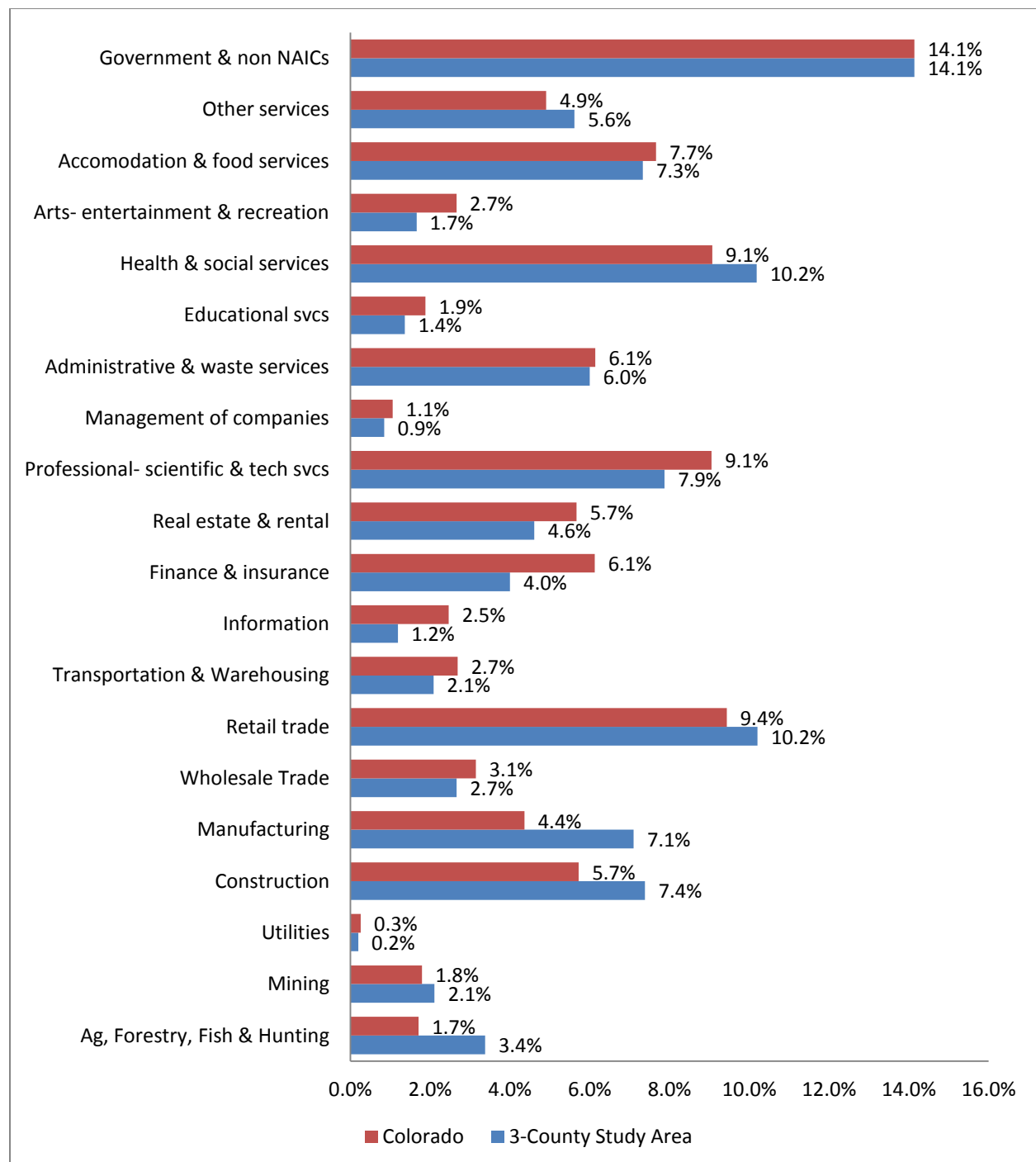
Source: Bureau of Labor Statistics, 2013

In the early nineties unemployment in Colorado and the PNG study area were low relative to national rates and remained below the natural rate until the early 2000's. Unemployment trends in the study area counties have mirrored state and national rates, although county rates have become more volatile over the past few years. This suggests that employment conditions in the study area have been similar to broader state and national trends but regional changes in the late 2000's have caused unemployment in Larimer, Logan, and Weld counties to deviate from state and national trends. Between 2010 and 2011 all three counties experienced considerable job losses in the retail trade, administrative support, transportation and construction sectors which paved the way for a net loss of thousands of non-farm jobs and created a twenty year high in unemployment within the PNG three-county study area.

Employment and Specialization

While many people identify a local economy as the one they directly participate in when they shop at small mom and pop stores within their own community. In reality, business patterns often cause people, goods, and services to flow between neighboring communities, counties, and even states. The constant flow of imports, exports, and commuting workers creates linkages between the communities within Larimer, Logan, and Weld counties which make up the local economy of the PNG study area. The local economy examined in the analysis of the PNG is diverse and supports employment in more than 300 industrial sectors. Figure 64 shows local employment in aggregated sectors as a share of total employment and compares shares within the study area to those at the state level (IMPLAN 2011). The largest industry within the three-county study area is the Government and non NAICs sector, which accounts for 14 percent of total employment across these three counties. Employment specialization can be examined using the ratio of the percent employment in each industry in the region of interest (Larimer, Logan, and Weld counties) to the percent of employment in that industry for a larger reference region (the state of Colorado). For a given industry, when the percent employment in the analysis region is greater than in the reference region, local employment specialization exists in that industry (USDA Forest Service 1998). Applying this criterion to 2012 data for the region allows the PNG study area to be characterized as being slightly specialized with respect to the Manufacturing (+1.7%), followed by the Ag, Forestry, Fish & Hunting sector (+0.3%).

Figure 66 Industry Employment



Source: IMPLAN 2012

Between 1998 and 2010 total employment in the three-county area increased from 146,661 to 171,959 jobs. Much of this growth can be attributed to growth in Services related sectors. Services related sectors include: Utilities, Wholesale Trade, Retail Trade, Transportation & Warehousing Information, Finance & Insurance, Real Estate & Rental & Leasing, Professional,

Scientific, & Tech., Mgmt. of Companies & Enterprises, Administrative & Support Services, Educational Services, Health Care & Social Assistance, Arts, Entertainment, & Recreation, Accommodation & Food Services, and Other Services, while Non-services related sectors consist of the following sectors: Mining, Construction, Manufacturing, and Agriculture, Forestry, Fishing, and Hunting. In 1998 71.3 percent of all employment in the three PNG study area counties was supported by Services related sectors. Between 1998 and 2010 employment in Services related sectors increased by 27 percent while employment in Non-Services related sectors declined by 8 percent, allowing employment in Services related sectors to grow to 77.4 percent of total employment in the PNG study area by 2010 (EPS-HDT 2011).

Personal Income

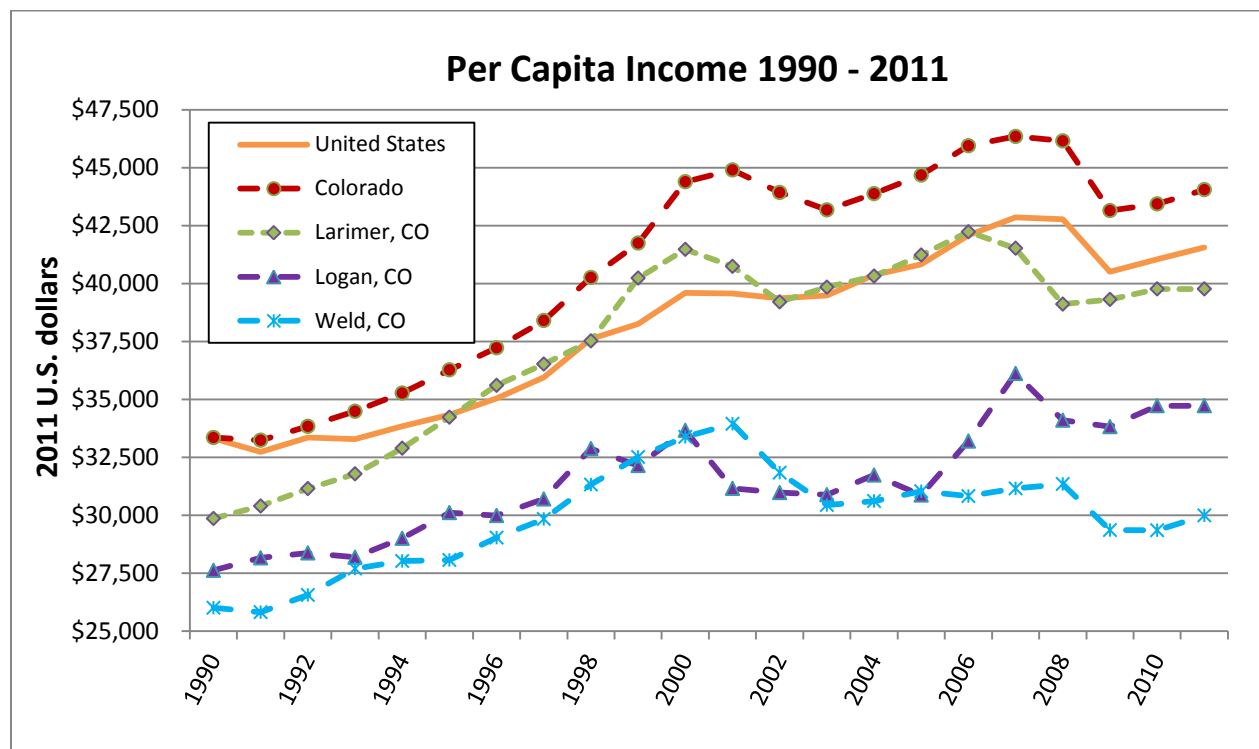
Personal income is a key indicator of the economic well-being of a county and provides a measure of all sources of income within the PNG study area. High personal income may signal greater job opportunities, highly skilled residents, greater economic resiliency, and well-developed infrastructure; while low personal income is often a reflection of poor economic conditions and the relatively few economic opportunities available within a county. Total personal income (TPI) in the study area exceeded \$20 billion dollars in 2010, with personal income in Larimer County accounting for more than half of TPI in the three counties. In 2010 TPI in Larimer County approached \$12 billion, while personal income in Logan and Weld exceeded \$799 million and \$7.5 billion respectively (adjusted for inflation and reported in 2011 dollars) (Bureau of Economic Analysis, 2012).

Per capita personal income (PCPI) measures average income per person in a region. PCPI in Colorado tends to be higher than PCPI at the national level. In 2010 Colorado's PCPI was slightly greater than \$44,000 while PCPI was approximately \$41,560 across the U.S and \$35,164 in PNG's three-county study area (adjusted for inflation and reported in 2011 dollars) (Bureau of Economic Analysis, 2012). While per capita personal income was below state and national levels in all study area counties, PCPI varied considerably across the Larimer, Logan, and Weld counties. In 2010, Larimer County had the highest PCPI at \$39,767, followed by Logan at \$34,725, while Weld had the lowest PCPI at \$29,345 (Bureau of Economic Analysis, 2012).

As shown by Figure 65, PCPI has been on the rise. Although per capita personal income in Colorado started off at relatively the same level as PCPI across the U.S. in 1990, average personal income across the state grew more rapidly than other states between 1990 and 2010. Over the last two decades PCPI in Colorado grew by 32 percent while PCPI across the nation rose by 25 percent (Bureau of Economic Analysis, 2012). While PCPI within the PNG study area remains below that of the state and the nation all three counties experienced considerable economic growth between 1990 and 2010. The average personal income of residents in Larimer County increased by 33 percent while PCI in Logan and Weld counties grew by 26 and 15 percent respectively. Though PCPI in Weld County has grown there continues to be a large

disparity between PCPI in Weld County and other regions included in the analysis. This disparity may be an indicator of increased employment in low paying sectors which has created a growing low income population (Bureau of Economic Analysis, 2012).

Figure 67 Per Capita Income



Source: Bureau of Economic Analysis, 2012

There are two major sources of personal income: (1) labor earnings or income earned through employment and (2) non-labor income. Labor earnings are typically the largest source of income within a region. In 2010 labor income accounted for 66 percent of all income within the three-county study area. Labor income in the three-county PNG study area has been supported by a wide range of industrial sectors. Using the same criterion utilized above to examine employment specialization, labor earning in Larimer, Logan, and Weld counties were shown to be most specialized in the Manufacturing (+5.6%), Construction (+3.4%), and Health & Social Services (+2.6) sectors (IMPLAN 2012). While the PNG supports employment and income in the three-county economy, the contributions of the Pawnee represent only a small portion of the total economic activity reflected in these industrial sectors.

Non-labor income includes investment income (dividends, interest, and rent payments) and transfer payments from the government to individuals (Retirement & disability insurance, medical payments, welfare assistance, unemployment, and veteran's benefits). In 2010 Non-Labor income within the PNG study area accounted for 34 percent of total personal income (TPI) in the three counties. As a share of TPI, investment income accounted for 20, 21, and 15 percent

in Larimer, Logan, and Weld counties while transfer payments accounted for 14, 19, and 18 percent of TPI in these respective counties (Table 8) (Bureau of Economic Analysis, 2012). More than 80 percent of transfer payments in the PNG study area were attributable to age related (retirement, disability insurance, and Medicare) or income maintenance (welfare assistance and Medicaid) programs. More than half of all transfer payments in Larimer, Logan, and Weld counties were age related and stemmed from Medicare and retirement and disability insurance benefits. While income maintenance payments accounted for more than 20 percent of transfer payments in the study area, disbursements from social programs which assist low-income individuals and households accounted for less than 4 percent of TPI in these three counties. These patterns reflect a moderate level of affluence and the importance of older residents, who receive age related transfer payments and are more likely to have investment earnings than younger adults, within the PNG study area

Table 78 Non-Labor Income as a Percent of Total Personal Income, 2010

	Total Personal Income (\$1000)	Total Non-Labor Income	Percent of Total Personal Income		
			Investment Income	Age Related Transfer Payments	Income Maintenance Related Transfer Payments
United States	\$ 12,743,579,426	35%	17%	10%	5%
Colorado	\$ 220,234,215	31%	18%	7%	3%
Larimer County	\$ 11,950,831	34%	20%	8%	3%
Logan County	\$ 799,258	39%	21%	11%	5%
Weld County	\$ 7,557,717	33%	15%	9%	5%

Source: Bureau of Economic Analysis Tables CA05N & CA35

While the population surrounding the PNG is relatively young compared to the state and nation, older residents play a significant role in the region's economy. As a greater number of the region's baby boomers retire age related transfer payments as a share of income from non-labor sources is likely to rise as long as residents continue to stay in the area after retirement or new retirees move in. Rural county population change, the development of rural recreation and retirement-destination areas are all related to natural amenities (Knapp and Graves 1989, Clark and Hunter 1992; Treyz et al. 1993, Mueser and Graves 1995, McGranahan 1999, Lewis et al. 2002, Poudyal et. al 2008). Many of the natural amenities in the area are managed by the PNG and thus, indirectly contribute to area labor and non-labor income. Communities with more

retired residents are typically more resilient to downturns in economic conditions since they are not dependent on employment as a source of income (USDA-USFS 2010). Additionally, while land protection can directly reduce employment growth, it has been shown that natural amenities can offset job losses due to increases in net migration (Eichman et al. 2010). Thus, the maintenance of natural amenities on the WRNF may play a role fostering an economy more resilient to change..

Poverty

Following the Office of Management and Budget's Directive 14, the Census Bureau uses a set of income thresholds that vary by family size and composition to detect who is poor. If the total income for a family or an unrelated individual falls below the relevant poverty threshold, then the family or an unrelated individual is classified as being "below the poverty level." In 2011 Colorado had a slightly smaller share of residents and families living below the poverty level relative to nation. While poverty rates for families in Larimer County were bellows those at the state and national level, poverty rates for individuals and families in Logan and Weld counties were equal to or exceeded those of the general U.S. population (U.S. Census Bureau 2012). Since low income individuals tend to rely more heavily on natural resources, higher poverty rates in Logan and Weld counties may indicate that residents in these counties are more likely to be directly affected by PNG management actions.

Table 79 Poverty Rates, 2011

	People Below Poverty	Families Below Poverty
United States	14%	10%
Colorado	13%	9%
Larimer County	13%	7%
Logan County	15%	11%
Weld County	14%	10%

Source: U.S. Census Bureau 2012

Housing Availability

While income can be an important indicator of the social and economic conditions, characteristics of local housing which provide insight in to the cost of living provides additional context. The American Community Survey (ACS) collects annual data on a wide range of community characteristics, including housing availability and costs. The most recent housing data for 2011 (Table 80) indicated that occupancy rates in three counties surrounding the PNG were slightly higher than rates at the state and national levels with only 9 percent of all housing units in the study area remaining vacant. Between the counties included in the study area occupancy rates were highest in Weld County (92%) and lowest in Larimer County (90%) (U.S. Census Bureau 2012). The majority of occupied units at county, state, and national level are

occupied by their owners, with owner occupancy accounting for more than 70 percent of all occupancy in Logan and Weld counties and approximately 67 percent of occupancy in Larimer County.

Table 80 Housing Availability, 2011

	Total Number of Housing Units	Occupied Units	Units Occupied by Owner	Home Owner Vacancy Rate	Rental Vacancy Rate
United States	131,034,946	114,761,359	66%	2%	8%
Colorado	2,197,823	1,941,193	67%	3%	7%
Larimer County	131,821	118,791	67%	2%	5%
Logan County	8,965	8,126	70%	4%	6%
Weld County	95,601	88,242	71%	3%	8%

Source: U.S. Census Bureau, 2012, Table: DP04

Occupancy rates are a direct reflection of how successful a community is at attracting and retaining residents. Areas considered desirable places to live tend to have lower vacancy home owner and rental vacancy rates relative to areas which offer fewer natural amenities and economic opportunities. In 2011 overall vacancy for the three county PNG study area (9%) was low relative to the state (12%) and nation (12%). Within the study area vacancies were lowest in Weld County (8%) and highest in Larimer County (10%) (U.S. Census Bureau, 2012).

These vacancy rates include two types of units, unoccupied units for sale and unoccupied rental units (Table 80) (U.S. Census Bureau, 2012). While the share of vacant homes up for sale in Colorado was slightly higher than the national rate, home owner vacancy rates in Larimer and Weld counties hovered around those at the state and national level. The share of unoccupied homes for sale in Logan County was slightly higher than the other reference areas, indicating a lower demand for permanent residency and investment properties compared to the surrounding area. The vacancy rate for rental units across the three-county PNG study area was comparable to that across the state (7%) with relatively low rental vacancy in Larimer (5%) and Logan (6%) and slightly higher rental vacancy in Weld County (8%).

Cost of Housing

Significant variations in home values across counties and between neighborhoods which make up local communities often cause average selling within larger areas to be misleading. To provide a more accurate representation of housing markets surrounding the PNG median or mid-point estimates of housing costs at the individual county levels are discussed in place of averages at larger scales. Table 11 provides median estimates of home values and monthly housing expenses for owners and renters at the county, state, and national level.

Table 81 Housing Costs, 2011

	Median Home Value	Median Selected Monthly Owner Costs	Median Gross Rent
United States	\$186,200	\$1,560	\$871
Colorado	\$236,700	\$1,656	\$ 883
Larimer County	\$244,600	\$1,614	\$887
Logan County	\$121,400	\$1,027	\$573
Weld County	\$193,300	\$1,558	\$801

Source: U.S. Census Bureau, 2012, Table: DP04

In general housing costs in Colorado exceed national medians and costs vary greatly between counties surrounding the grasslands (table 76). In 2011 Larimer County home values were highest in Larimer County where the selling price for the median home exceeded that of the state and nation. Homes in

Study Area Well-Being

Community well-being relates to the economic, social, cultural, and political components of community life which allows residents to fulfill their basic needs, while creating an enjoyable place for citizens to live. While many factors contribute to quality of life in a region; employment, personal income, poverty, and crime are the most commonly used social indicators of well-being.

Employment

As discussed above in the employment section, labor participation in Larimer, Logan, and Weld counties has been high historically, but unemployment rates within the PNG study area have become increasing volatile in recent years. Employment in Services related sectors has increased as a share of total employment while Non-services related sectors share of total employment has been declining. In general, jobs in Service related sectors pay lower wages than those in Non-services sectors, thus increases in the percent of total employment attributable to these sectors could decrease area economic well-being. Within the three-county area the Services and Non-services related sectors paid average annual wages of \$36,299 and \$54,584, respectively in 2010 (U.S. Department of Labor 2012). Thus, increases in employment in sectors associated with lower wages alongside decreases in sectors associated with higher wages could indicate a decrease in area economic well-being. However, we cannot say that decreases in economic well-being have resulted from increases in Service related sector employment, since higher labor force participation in the Services related sectors, by groups such as women and minorities, could increase the overall importance of certain sectors over others.

In addition, many people migrating to the area may have moved for the region's unique natural and cultural amenities and the lower wages paid in Services related sectors may be offset by the personal enjoyment these residents gain from cultural and outdoor experiences. In this manner some residents may earn a "secondary income" from the natural amenities of their communities

which complements the income earned from their employer. Natural amenities, often provided by public lands, have been found to influence population and employment changes in amenity rich communities (Knapp and Graves 1989, Clark and Hunter 1992, Treyz et al. 1993, Mueser and Graves 1995, McGranahan 1999, Lewis et al. 2002). As a steward of Northern Colorado's unique natural and cultural amenities, the PNG increases the attractiveness of local communities and supports a portion of population and employment growth in the area.

Personal Income

Total personal income (TPI) and per capita personal income (PCPI) are useful measures of economic and social wellbeing. From 1970 to 2011, annual TPI in the three-county PNG study area increased from \$4 billion to \$20.3 billion, and annual PCPI increased from \$20,005 to \$35,164 (all measures adjusted for inflation to 2011 dollars). This translates to a TPI increase of 408 percent and a PCPI increase of 76 percent over this time period (US Bureau of Economic Analysis, 20012). While PCPI is a useful measure of economic wellbeing it should be examined alongside changes in real earnings per job. Since PCPI includes income from 401(k) plans as well as other non-labor income sources, such as transfer payments, dividends, and rent, it is possible for per capita income to rise, even if the average wage per job declines over time. Although labor earnings have historically been the largest source of income in the PNG study area, its share of TPI has slightly declined from 75 percent to 66 percent between 1970 and 2010. As the importance of labor income to regional income has declined, the share of non-labor income has risen from 25 percent to 34 percent. Increased shares of non-labor income resulted from investment income increasing from 16 to 19 percent and transfer payments increasing from 9 to 16 percent of TPI. While transfer payments' share of TPI rose during this period, data indicated this increase was only slightly due to increased age related payments related to Medicare and retirement and disability insurance benefits. Much of the PNG study area's increased reliance on transfer payments is attributed to income maintenance payments related to welfare or unemployment which accounted for 17 percent of all transfer payments during 2010. The distribution of transfer payments varied across counties in the study area with Larimer County receiving the majority of unemployment benefits and Weld County received the majority of welfare payments. In 2010 Larimer County received more than \$123 million in unemployment benefits and residents in Weld County received \$137 million in welfare payments (US Bureau of Economic Analysis, 2012).

Poverty

Poverty is an import indicator of both economic and social well-being. Individuals with low incomes are significantly more likely to experience a wide range of problems and increase their risk for problems with health, cognitive development, socially unacceptable behavior, emotional well-being, and school achievement (Williams 1984, Patterson 1991, Haan et. al 1986, Battistich et. al 1995, Farrington 1995, Chung 2004, Hopson and Lee 2011).

As discussed earlier, poverty rates in Colorado follow those of the nation relatively closely. While poverty rates for individuals and families within the PNG study area hover around those

of the state and the nation, Logan and Weld counties had a larger share of single mother families living in poverty. In 2011 more than 30 percent of all single mother households in Logan and Weld fell below the poverty line. Those with young children were shown to be at even greater risk of poverty. When compared to state and national statistics Logan (50%) and Weld (41%) counties both had a higher percentage of single mother households with children under 18 in poverty.

Table 82 Detailed Poverty Rates, 2011

	United States	Colorado	Larimer County	Logan County	Weld County
People	14%	13%	13%	15%	14%
Under 18 years	20%	17%	13%	23%	18%
65 years and older	9%	8%	6%	8%	9%
Families	10%	9%	7%	11%	10%
with related children < 18 years	16%	14%	11%	19%	15%
Married couple families	5%	5%	4%	4%	6%
with children < 18 years	7%	7%	5%	7%	8%
Single Mother households	29%	27%	24%	39%	32%
with children < 18 years	38%	35%	32%	50%	41%

Source: EPS-HDT, 2013

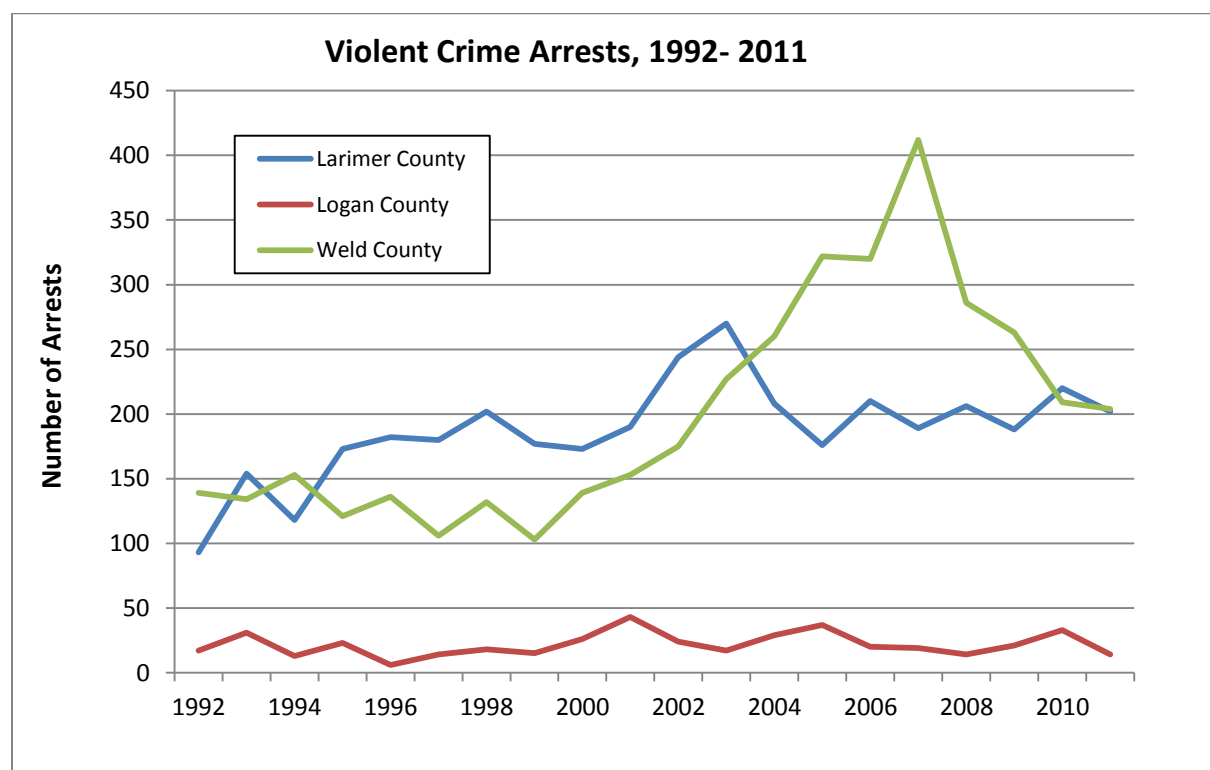
Crime

Violent crime can be an indicator of the sense of community residents have within their neighborhoods and the susceptibility of these areas to social chaos. The sudden influx of workers associated with the boom and bust cycles of oil and gas development have been shown to introduce social instability into once quite communities. Social instability following rapid growth related to oil and gas development has been associated with reduced civic participation and social integration, diminishing the quality of community life, and with increases in domestic violence, crime, and drug use (Vohrs 1974, Brookshire and D'Arge 1980, Kelly 1980, Kittredge, 1987, Brown et. al 1989, Freudenburg and Jones 1991, Karl 2004, Cohen et. al 2007, Berger and Beckman 2009, Brown 2011, Ruddell 2011). Violent crimes, which include murder, forcible rape, robbery, and aggravated assault, have the ability to leave lasting scars on a community. Similar to how increased availability and proximity to quality housing, schools, jobs, and human services have social and economic benefits which increase the quality of community life, there are economic and social costs associated with crime and the increased risk of being victimized. have an economic cost associated with mitigating these risks and a larger social cost which reduces the quality of life for long-term and existing residents.

Relative to state and national statistics, considerably fewer violent crimes takes place in the PNG study area. In 2011 the three county study area had 71.7 arrests for violent offenses per 100,000 inhabitants while the state reported 144 and the nation 386.3 (FBI 2012, ORS 2012). Crime rates often fluctuate with changing social and economic conditions; figure 41 shows violent crime in

the study area over the last twenty years. While crime in Logan County has remained fairly constant, there has been a slight upward trend in violent crime in Larimer and Weld counties. Over the last twenty years Larimer has averaged 3 murders, 25 forcible rapes, 18 robberies, and 141 aggravated assaults a year while Weld County averaged 5 murders, 14 forcible rapes, 20 robberies, and 161 aggravated assaults. While crime has been trending downward in Larimer since 2003, violent crimes were on the rise in Weld County during most of the 2000's. Though the county experienced small increases in murder, rape, and robbery between 1999 and 2007 much of this increase stemmed from aggravated assaults, which rose from 81 offenses in 1999 to 359 in 2007.

Figure 68 Violent Crime 1992-2011



Source: Office of Research and Statistics, 2012

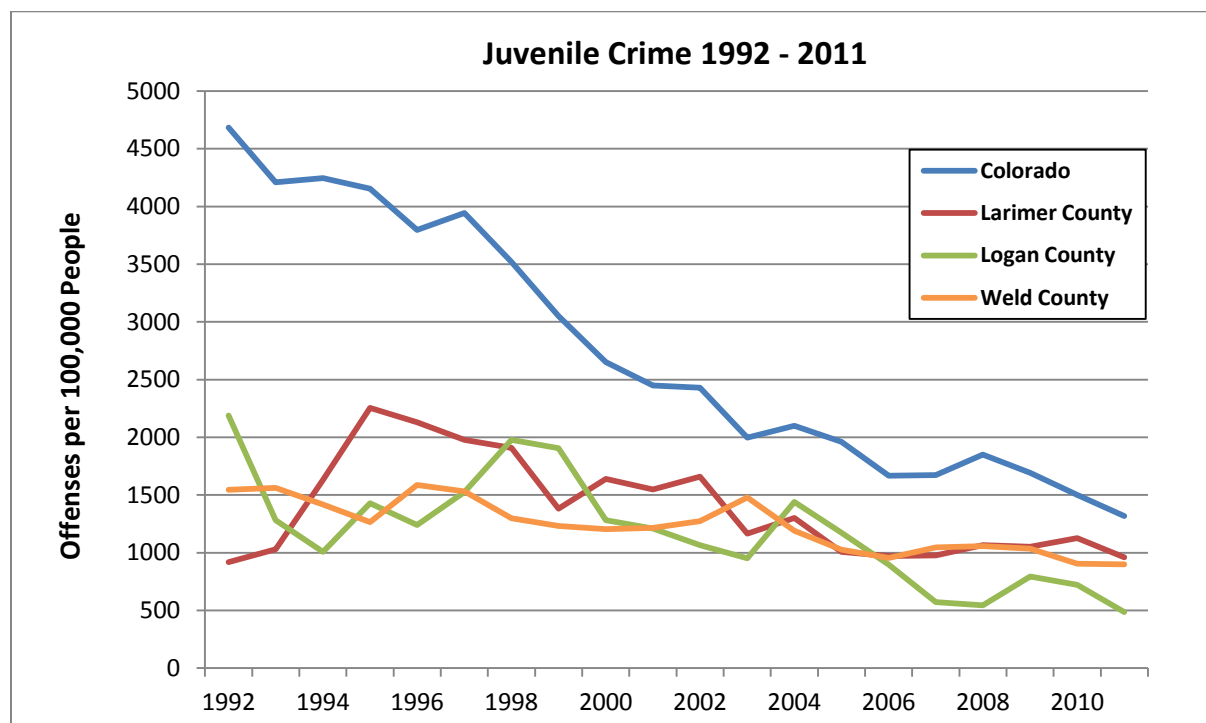
Crime has been linked to many socioeconomic factors including population growth and density, income, education, and family disturbances. Children raised in households with frequent family disturbances often experience abuse and/ or neglect which later manifests into developmental and behavioral problems in young men and women (Messner and Sampson 1991, Zingraff et. Al, 1993, Fagan 1995, Chapple et. al 2005, Widom 2006, Douglass et. al 2010). Juvenile crime and delinquency is frequently traced back to family and marital avoidance, dysfunction, conflict, and instability. Since many of the needs and desires of children from broken homes go unmet, juveniles from broken homes tend to have a much weaker sense of connection to their neighborhoods, making them more likely to exploit members of their own community (Fagan

1995). While it is difficult to measure the stability of individual households in the PNG study area, statistics on juvenile crime may provide insight into the overall stability of family life within Larimer, Logan, and Weld counties.

Figure 67 shows juvenile arrests per 100,000 people at the state and county level between 1992 and 2011. Over the last twenty years Colorado crime rates have steadily declined. The number of adolescent offenses per 100,000 people within the PNG study area is much lower than the rate for all of Colorado. While juvenile crime rates remained relatively constant in Weld County over the last two decades, criminal activity by minors in Larimer and Logan counties had greater fluctuation. Both counties saw juvenile crime rise during the nineties, with adolescent crime peaking in Larimer in 1995 and in Logan in 1998. Since peaking in the mid-nineties Larimer County has seen a very strong downward trend in juvenile crime while Logan County experienced another spike in crime by minors between 2003 and 2004.

While dysfunctional families certainly still exist within the PNG study area, juvenile crime rates as a proxy for family and marital avoidance, dysfunction, conflict, and instability indicate that adolescents in the study area are less affected by these problems than youth in other parts of Colorado. Trends over the last twenty years suggest that the general well-being of children at home has remained about the same in Weld County and has gradually improved in Larimer and Logan counties.

Figure 69 Juvenile Crime 1992-2011



Source: Office of Research and Statistics, 2012

Environmental Justice

In 1994, President Clinton issued Executive Order 12898. This order directs federal agencies to focus attention on the human health and environmental conditions in minority and low-income communities. The purpose of EO 12898 is to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects on minority and low-income populations.

Environmental justice (EJ) is the fair treatment and meaningful involvement of people of all races, cultures, and incomes, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. The goal of environmental justice is for Federal agency decision-makers to identify impacts that are disproportionately high and adverse with respect to minority and low-income populations and identify alternatives that will avoid or mitigate those impacts. According to USDA DR5600-002 (USDA 1997), EJ, minority, minority population, low-income, and human health and environmental effects, are defined as follows:

Environmental Justice means that, to the greatest extent practicable and permitted by law, all populations are provided the opportunity to comment before decisions are rendered on, are allowed to share in the benefits of, are not excluded from, and are not affected in a disproportionately high and adverse manner by, government programs and activities affecting human health or the environment.

Minority means a person who is a member of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.

Minority Population means any readily identifiable group of minority persons who live in geographic proximity to, and, if circumstances warrant, migrant farm workers and other geographically dispersed/transient persons who will be similarly affected by USDA programs or activities.

Low-Income Population means any readily identifiable group of low-income persons who live in geographic proximity to, and, if circumstances warrant, migrant farm workers and other geographically dispersed/transient persons who will be similarly affected by USDA programs or activities. Low-income populations may be identified using data collected, maintained and analyzed by an agency or from analytical tools such as the annual statistical poverty thresholds from the Bureau of the Census' Current Population Reports, Series P-60 on Income and Poverty.

Human Health and/or Environmental Effects as used in this Departmental Regulation includes interrelated social and economic effects.

The emphasis of environmental justice is on health effects and/or the benefits of a healthy environment. The CEQ has interpreted health effects with a broad definition: "Such effects may include ecological, cultural, human health, economic or social impacts on minority communities,

low-income communities or Indian Tribes ...when those impacts are interrelated to impacts on the natural or physical environment” (CEQ, 1997).

Based on the data presented in the previous Population and Demographics and Employment, Income, and Housing section, it appears unlikely that environmental populations within the PNG study area would be disproportionately affected by Forest Service management actions. Data indicated that Larimer, Logan, and Weld counties had low concentrations of racial, ethnic, and low income populations relative to the state and the nation, reducing the likelihood of these groups experiencing disproportionately high and adverse effects related to changes in management actions. Since smaller areas within the PNG study area may have higher concentrations of EJ populations, the impact analysis will continue to consider the potential for management actions to disproportionately negatively affect environmental justice populations within the study area.

Forest Users and Contributions

Communities Interested in the Management of Pawnee National Grasslands

The uses, products, services, and visitor opportunities supported by the Pawnee National Grasslands provide communities with a steady flow of benefits. Communities dependent on Nation Forest System Lands can be identified by their geographical location and by their connections to the local landscape. This distinction is best characterized as the difference between communities of place (i.e., people who are bound together because of where they reside, work, visit or otherwise spend a continuous portion of their time) and communities of interest (i.e., people who share a common interest or passion, regardless of their location or degree of interaction) (Patterson et al., 2003). Geographically defined communities are an important and relevant level for social assessment because the most critical impacts of federal land management are often felt by small, rural communities (USDA USFS 2000). However, the geographically based community refers to physical or political boundaries and not to the relationships among people who reside within these boundaries. While contributions to communities of place can be measured in terms of the economic activity forest resources support in the local economy, the social and cultural links between the forest and communities of interest often transcend the boundaries of a physical place. Brown and Duguid describe communities of interest as —communities-of-communities (Brown and Duguid 1991); they provide unique opportunities to explore the linkages between people and public land that may transcend the geographically defined community.

- natural landscapes and scenic beauty
- outdoor recreation and public land access
- wildlife
- grazing
- oil and gas exploration and development

Forest Contributions

The Pawnee National Grasslands are managed in accordance with the Multiple-Use Sustained-Yield Act of 1960 (16 U.S.C. 528–531) (MUSYA) to sustain the multiple uses of its renewable resources while maintaining the long-term health and productivity of the land. The PNG's resources are managed for the long-term social and economic benefit of human communities. Economic benefits of managing forest resources can be measured in terms of the jobs and income which they support in forest related industries. In addition to the economic activity directly supported by Forest Service employment and management expenditures, the utilization of forest's resources supports economic activity in a number of industrial sectors, including local Recreation & Tourism, Livestock production, and Oil and gas exploration and development. Economic activity in these forest related industries further stimulates economic activity in non-forest related and supporting industrial sectors. The employment and labor income generated in these seemingly unrelated sectors are known as the secondary, or indirect and induced effects of economic activity supported by the forest.

Outdoor Recreation and Tourism

Outdoor recreation and access to public lands have been attributed with attracting and sustaining families and businesses, creating healthy communities and fostering a high quality of life. It is estimated that more than three out of every four Americans participate in active outdoor recreation each year and more than 140 million Americans make outdoor recreation a priority in their daily lives (Outdoor Industry Association , 2012). As one of the country's leading hot spots for outdoor recreation, Colorado's forests, parks, and rivers attract millions of visitors each year. These recreationists spend money on gear, vehicles, trips, and travel-related expenses which support jobs and income, and generate tax revenues in local communities. On annual average, the outdoor recreation and tourism industry is valued at more than \$10 billion, supporting approximately 107,000 jobs and generating nearly \$500 million in tax revenue across Colorado (Outdoor Industry Association, 2012).

Undeveloped lands across the state provide local residents, out-of-state visitors, and international travelers with high quality outdoor experiences. While outdoor recreation by non-local recreationists is responsible for injecting millions of new revenue into the state's economy each year, access to exceptional outdoor experiences close-to-home adds to the quality of life enjoyed by local residents and increases the attractiveness of Colorado communities as places to live and work. The PNG provides a wide array of recreational opportunities which are enjoyed by local and non-local residents. The large expanse of undeveloped lands and unique opportunities on those lands attracts recreational visitors who participate in activities such as hiking, mountain biking, camping, ATV riding, four wheel driving, horseback riding, recreational shooting, and wildlife viewing. On their way to the PNG and once they arrive these visitors spend money on goods and services they would spend elsewhere if these opportunities did not exist. In this

manner the opportunities on the PNG contribute to the local economy by attracting and maintaining local outdoor recreation related spending in communities surrounding the PNG.

Consequently, changes to PNG habitat and its landscape from oil and gas leasing and development could affect these contributions. The removal of federal lands from resource use can have positive effects on local employment with increased population migration related to recreation and other natural amenity based uses (Eichman et al. 2010). However, the degree to which these uses could offset losses cannot be anticipated.

Grazing and Livestock Production

Agriculture is deeply rooted in the heritage and culture of Colorado and continues to be an integral part of the state's economy. Consistently ranked as one of top 20 producing states in the U.S., Colorado's agricultural sector was valued at more than \$7.7 billion in 2012. Although the state produces a wide array of agricultural goods, cattle are the backbone of Colorado agriculture and account for 56 percent of the state's agriculture receipts (NASS, 20014). In 2012, Colorado's cattle industry was valued at more than \$4 billion with a statewide inventory of more than 2.6 million cattle and calves (NASS, 20014). Cattle and calves are grazed on Colorado's mountainsides and plains, while most of the state's beef cattle are fattened on feedlots around Greeley, CO.

Table 83 January 1st Cattle and Calve Inventories, 2003-2013

	Larimer County	Logan County	Weld County
2003	52,000	212,000	546,000
2004	42,000	179,000	520,000
2005	40,000	185,000	505,000
2006	36,500	183,000	550,000
2007	35,000	186,000	549,000
2008	51,000	195,000	565,000
2009	49,000	185,000	535,000
2010	48,500	185,000	535,000
2011	49,000	190,000	545,000
2012	51,000	195,000	565,000
2013	48,000	185,000	535,000

Source: NASS. Quickstats 2.0

A large portion of the land base in the study area is dedicated to agricultural use, of which livestock production is the most common activity. Many families depend on livestock grazing as a source of income; but it also supports a way of life and family traditions. Table 12 reports the volume of cattle and calves by county. In the last 10 years the volume of cattle in the study area has remained relatively steady. Although there have been some fluctuations caused by changes

in environmental and market conditions, there have not been any major increasing or decreasing trends in county inventories. In 2012, cattle ranching and farming supported approximately 0.2, 4.8, and 2.3 percent of total employment and 0.1, 3.2, and 1.3 percent of total employee compensation and proprietor's income, respectively, in Larimer, Logan, and Weld counties (IMPLAN, 2012). These statistics illustrate how Logan and Weld counties are much more economically dependent on cattle ranching and farming than neighboring Larimer County.

While a number of large commercial feed lots operate within Logan and Weld counties, many smaller independent operations continue to raise cattle in grass filled pastures. These local ranchers rely on a mixture of private, state, and federal lands to provide the majority of their herds' annual forage needs. Grazing is authorized on the Pawnee under the Taylor Grazing Act and FLPMA for the purpose of fostering economic development for private ranchers and ranching communities by providing ranchers access to additional forage (GAO, Sept. 2005). The Forest Service administers access to forage on the PNG through a combination of direct permits and agreements with the Crow Valley Livestock Cooperative, Inc. and the Pawnee Cooperative Grazing Association. Although the Pawnee's grazing potential has been estimated to be more than 48,000 AUMs a year, grazing is often restricted below its full potential because of factors such as drought, rangeland conditions, changes in active permit holders, financial limitations on operators and market conditions. The last decade has been very dry and persistent drought conditions have reduced the quality and quantity of available forage. Although permits may entitle local ranchers to additional AUMs, many have taken voluntary reductions in recent years to maintain good range conditions. In 2013, the Forest Service only billed for three-fourths of permitted AUMS (36,656 AUMs).

Local ranchers who graze livestock on allotments within the amendment area pay federal grazing fees. The annually determined grazing fee is computed by using a 1966 base value of \$1.23 per AUM for livestock grazing on public lands in Western states. The figure is then calculated according to three factors – current private grazing land lease rates, beef cattle prices, and the cost of livestock production. In effect, the fee rises, falls, or stays the same based on market conditions, with livestock operators paying more when conditions are better and less when conditions have declined. The formula used for calculating the grazing fee, which was established by Congress in the 1978 Public Rangelands Improvement Act, has continued under a presidential Executive Order issued in 1986. Under that order, the grazing fee cannot fall below \$1.35 per AUM, and any increase or decrease cannot exceed 25 percent of the previous year's level. In 2013 livestock grazing on the PNG generated \$49,486 in federal revenue. A portion of which is distributed back to these counties to fund schools, roads, and range improvement projects.

Federal grazing fees have remained constant at the minimum \$1.35/AUM for the past eight years. Relative to the statewide average of \$17.00 per AUM, Federal lands appear to be the least expensive grazing land available (NASS, 2013). Grazing fees are only a small portion of the total cost of grazing on federal public lands, however. In general, private rangelands conditions are of higher quality and provide ranchers with fences, roads, salt and water, and protection for livestock. On public lands, ranchers must provide these themselves. Once additional costs associated with grazing on public lands are factored in, the cost differential between public and private grazing fees disappears. In many cases, the total cost of a public land AUM exceeds the total cost of a private land AUM (Rimbey and Torrell, 2011). Even though ranchers incur additional costs to graze on federal lands, federal grazing permits are coveted by ranchers. In addition to granting permit holders access to forage during a critical period of the year when forage on private hay fields and meadows is being grown, federal grazing permits add to the resale value of local ranches.

In addition, to the value of forage supplied by federal lands, livestock grazing on these grasslands supports local area employment and income. Since the distinction between farm and home is often not well-defined, the majority of the labor used in agricultural production is provided by unpaid family workers and is not reflected in general industry reporting. Traditional labor statistics only reflect hired employment, which are estimated to make up only one-third of the total workforce in the agricultural sector (Kandel, 2008). When labor contributions of unpaid family workers are considered alongside those of hired agricultural workers, the farming and ranching is revealed to play a much larger role in the local economy. In terms of local area contributions from Forest Service supplied forage, permitted use levels of grazing on the Pawnee support 102 total jobs⁵¹ and approximately \$1.8 million in local labor income (direct, indirect and induced wages and proprietor's income) on an average annual basis.

While grazing on the Pawnee can only be attributed with supporting a small share of economic opportunities in surrounding communities, this forage is essential to supporting traditional ranching lifestyles in Logan and Weld counties. Most ranching families view raising livestock as more of a tradition than a job and only obtain a small portion of their household income from livestock production. Many ranches are dependent upon one or more family members working off-ranch and continue to raise livestock because the tradition is often deeply rooted in their personal history and identity. Livestock ownership and ranch life are powerful forces that bind communities and families, and responsibility toward land and livestock are often enmeshed in family values. Continuing this way of life maintains traditional values and connects families to ancestral lands and heritage. Thus, the economic development for private ranchers and ranching

⁵¹ This measure of employment is not in terms of full-time equivalents and includes all full-time, part-time, seasonal, and unpaid family labor positions associated with livestock grazing on pastures administered by the Pawnee National Grasslands. Thus, IMPLAN employment can be interpreted as 1 job lasting 12 months = 2 jobs lasting 6 months each = 3 jobs lasting 4 months.

communities supported by Pawnee's rangeland contributes to the sustainability of traditional ranching lifestyles.

Oil and Gas Exploration and Development

The diverse geography and geology of Colorado provides the state with an abundance of conventional and renewable energy resources. Colorado's various energy resources include substantial oil, natural gas, coal, hydroelectric, and wind. In 2011, Colorado ranked 7th among the states in terms of total energy production, producing 2,747 trillion Btu's (Department of Energy 2012). Fossil fuels account for a large share of the state's energy resources. Colorado contains 10 of the Nation's 100 largest natural gas fields and three of its 100 largest oil fields (Department of Energy 2010). Technological advances in hydraulic fracturing and horizontal drilling have increased the recoverability of Colorado's minerals and enabled production in many parts of the state to grow rapidly. Between 2007 and 2012, crude oil production in Colorado rose 89% while marketed natural gas production rose 38%. By 2012, Colorado ranked 6th in natural gas production (7 percent of U.S. total production) and 9th in crude oil production (2 percent of U.S. total production) (Department of Energy 2014).

Colorado's recent oil boom has largely been attributed to increased production in the Northeastern Denver-Julesburg (DJ) Basin, which extends from the Denver-Aurora Metropolitan Area into parts of Wyoming, Nebraska, and Kansas. Although Geologists have long known of the basin's vast petroleum reserves, most of these minerals were believed to be too difficult and expensive to extract. Advances in horizontal drilling coupled with the development of multiple-stage fracking have drastically increased producers' ability to economically extract oil and natural gas from tight shale plays deep within the basin. Although Larimer, Logan, and Weld counties account for a relatively small part of the DJ Basin, approximately 41 percent of Colorado's active wells were located in these counties in 2013 - Larimer (254 wells), Logan (230 wells), and Weld (20,684 wells) (Department of Energy 2013).

The oil and gas industry is an important part of the regional economy. Operations and support services associated with the exploration, drilling, and extracting petroleum products supports thousands of local jobs and millions of dollars in labor and proprietor's income in the three-county analysis area. In 2012 oil and gas development in Larimer, Logan, and Weld counties was estimated to support 1,824 jobs related to petroleum product extraction, 285 associated with drilling, and another 4,388 in support activities for operations (IMPLAN, 2012). In addition to employment directly associated with oil and gas development, the industry's capital investment in new structures and equipment further stimulates economic activity and employment opportunities in other sectors of the economy.

Most of these economic opportunities are supported by oil and gas related activities in Weld County. Weld County has become the epicenter of recent oil and gas drilling in Colorado and is

anticipated to soon become the state's top oil and gas producing county. In 2012, Colorado approved 3,773 permits to drill in Weld County, which accounted for 48 percent of all permits approved that year (Department of Energy 2013). Development associated with oil and gas occurs on both public and private lands in Weld County. Currently the Pawnee National Grasslands has 62 active oil and gas wells and 199 plugged or abandoned wells. Fifty-five percent of PNG's active wells produce crude oil and natural gas, while the remaining 7 are used as injection wells to stimulate production of nearby producing wells and to store natural gas for later production. According to the Office of Natural Resource Revenue (ONRR), federal minerals within the Pawnee produced 19,913 barrels of oil and 35,162 MCF of natural gas in 2012 (ONRR, 2013). Based on average statewide wellhead prices reported by the Independent Petroleum Association of America (IPAA)⁵², oil and gas production on the Pawnee was valued at more than \$1.9 million 2012 (IPAA, 2013). Although only 2 jobs and \$99,500 in labor income can be attributed to production of federal minerals on the PNG on an average annual basis, additional employment and income may be associated with approved drilling activities (IMPLAN 2012).

The federal government receives revenue from bonuses, royalties and rentals from mineral leases issued under the authority of the Mineral Leasing Act for Acquired Lands (30 U.S.C. § 351). Parcels approved for leasing are offered by the BLM at lease sales for a minimum rate of \$2.00 per acre. These sales are competitive and parcels with high potential for oil and gas production command bonus bids in excess of the minimum bid. While federal minerals on the Pawnee have not been auctioned for leasing in several years, private and state trust lands have recently commanded large bonus bids. State administered minerals in Weld County sold at the May 2014 lease sale earned an average bonus bid of \$638 per acre and limited information from private parcels have ranged from \$125 per acre up to a reported sale of over \$10,000 per acre. In addition to bonus bids, lessees are required to pay rent annually until production begins on the leased parcel, or until the lease expires. These rent payments are equal to \$1.50 an acre for the first five years and \$2.00 an acre for the second five years of the lease. Currently there are 43,444 acres of Federal minerals leased within PNG boundaries. Annual rental revenue to the Federal Government from leasing Federal minerals on the Pawnee is estimated to be \$45,395⁵³.

As mentioned above, Federal oil and gas production is subject to royalties. Federal oil and gas royalties, which are a form of excise tax, are equal 12.5 percent of the value of production (43 CFR 3103.3.1). While annual royalties fluctuate based on wellhead prices and the volume of production, the Federal Government was estimated to have collected approximately \$241,400 from oil and gas production on PNG in 2012. Forty-nine percent of which, is distributed back to the State of Colorado in accordance with the Mineral Leasing Act for Acquired Lands. In

⁵² Statewide average wellhead prices in 2010 were \$88.26 per bbl. for crude oil and \$4.94 per MCF for natural gas

⁵³ This was estimated under the assumption that half of all currently leased acres not held by production are in the first 5 years of their lease and the remaining half are in the second 5 years of their lease

addition to Federal taxes on production, Colorado levies three direct taxes on production – the first by the county where the production occurs, the second by the state, and the third by the Colorado Oil and Gas Conservation Commission (COGCC).

Ad valorem taxes are assessed on the actual value of oil and gas production and paid directly by producers to the county. Relative to other Colorado petroleum producing counties, Weld County's property taxes are high with an effective tax rate of 8 percent (COGCC, 1997). Based on 2012 production from federal minerals on the PNG, Weld County collected nearly \$154,500 in county revenue from oil and gas production on the Pawnee. Although oil and gas production in Colorado is subject to a progressive state severance tax which ranges from 2 to 5 percent of gross income, Colorado Law allows state severance taxes to be reduced by a credit equal to 87.5 percent of ad valorem taxes paid. Depending on the applicable severance and ad valorem tax rates, the severance tax liability of working or royalty interest owners can be reduced to \$0. While severance tax dollars are collected based on the value of production (minus a number of credits, exemptions, and deductions) and property local property tax mills, these revenues are distributed based on production and the number of industry workers in a county. As a result, Colorado's tax structure has created a loophole where production in counties with high property tax mills is virtually untaxed at the state level. Weld County is a prime example of this. Although Weld County is one of the top oil and gas producing counties, the state collected less than 20 percent of 2013 energy severance taxes from production in this county (COGCC, 2014).

Oil and gas companies are also required to pay a conservation levy every quarter. As of July 2007, the charge is 0.07% of oil, natural gas, and CO₂ production sales, less exemptions. This levy rate is designed to meet the expenses of the Colorado Oil and Gas Conservation Commission, the state agency responsible for regulating oil and gas development.

Federal Payments to Local Government

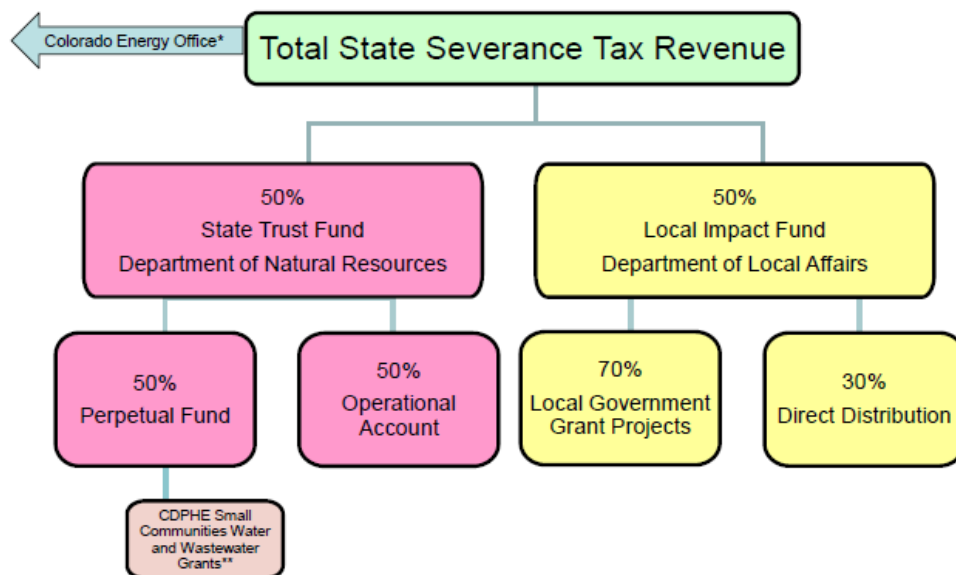
The US Forest Service makes payments to states and counties that contain NFS lands. These payments fall into two categories: Payments in Lieu of Taxes (PILT) and Secure Rural Schools and Community Self-Determination Act payments (SRSCS). Federal agencies do not pay property taxes; therefore, PILT is distributed to counties to compensate for the local services that support activities on federal lands. These services include law enforcement, road maintenance, and fire departments.

SRSCS payments redistribute a share of revenue generated from activities on Forest Service Lands back to the counties. These payments are intended to improve public schools, maintain infrastructure, improve the health of watersheds and ecosystems, protect communities, and strengthen local economies.

While future oil and gas development on the Pawnee is unlikely to affect the number of Forest Service managed acres eligible for PILT payments, increased exploration and development of the PNG's mineral resources could increase in SRSCS payments over the next twenty years.

In addition to payments from US Forest Service, a portion of state and federal revenue generated from the leasing and production of federal minerals on the Pawnee are returned to Weld County. Figures 5 and 6 show how state and federal revenue derived from energy and mineral extraction are distributed in Colorado. Half of State Severance Tax receipts go to the state Department of Natural Resources, while the other half is distributed by the Department of Local Affairs (DOLA) to areas impacted by oil and gas development. Approximately 30 percent of State Severance Tax receipts are allocated into “county pools” based on each county’s proportion of industry employee residents, mining and well permits and mineral production compared to the totals statewide. The Department then distributes each county pool to the county government and each municipality therein based on the unincorporated or municipal proportions of employee residents, population, and road miles compared to the total in the county.

Figure 70 Distribution of State Severance Tax Receipts



*Annual \$1.5 million from total gross receipts to Innovative Energy Fund through July 2016.

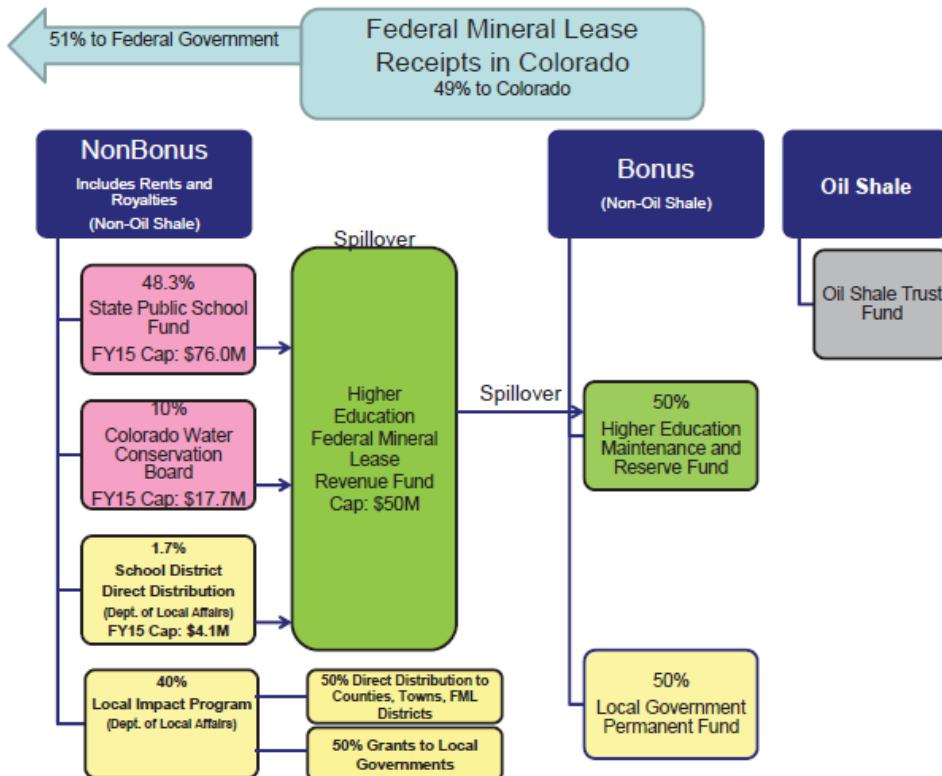
** Up to \$10 million after \$50 million to Perpetual Fund (CRS 39-29-109(2)(a)(III)).

Source: Colorado Department of Local Affairs, 2014

Under the Mineral Leasing Act for Acquired Lands, 49 percent of the federal revenue generated from oil and gas related activities on the PNG is returned to Colorado for planning, construction and maintenance of public facilities in areas socially and economically impacted by the mineral leasing development on federal lands (30 U.S.C. § 351). Figure 5 shows how Colorado distributes bonus and non-bonus revenues from the state's Mineral Leasing Fund. Revenues associated with bonuses on federal mineral leases are not distributed directly back to producing counties. Under current law, bonus payments are split between the Higher Education Maintenance and Reserve Fund and Local Government Permanent Fund. Moneys in the permanent fund generally remain in the permanent fund, but may be appropriated by the general assembly when the March revenue estimate in any fiscal year indicates that the total amount of moneys that will be deposited into the mineral leasing fund during that fiscal year is anticipated to be at least 10 percent less than the amount deposited in the preceding fiscal year (SB14-106).

A portion of federal non-bonus revenue from rents and royalties is returned to the state are used to fund public schools and water projects throughout Colorado, and to mitigate local impacts of oil and gas development in producing counties (Figure 69). Nearly forty-two percent of these revenues are allocated into "county pools" based on each county's proportion of resident industry employees and federal mineral lease revenues generated compared to the totals statewide. The DOLA then distributes each county pool to the county government and each municipality therein based on the unincorporated or municipal proportion of employee residents, population and road miles compared to the total in the county.

Figure 71 Distribution of Federal Mineral Lease Revenue in Colorado



Source: Colorado Department of Local Affairs, 2014

While distributions of Colorado's mineral leasing revenues fluctuates each year, these payments provide Weld County (and municipalities within the county) with millions of dollars of public revenue each year. Direct county, municipality, and federal mineral leasing district distributions to Weld County in fiscal year 2013 exceed \$7.6 million. This included more than \$5.2 million from state severance tax receipts, \$191,000 for local school districts, and \$2.2 million in direct county and municipal payments (DOLA, 2014). Annual oil and gas related payments from the DOLA are used to provide public services and invest in local infrastructure improvements which benefit local residents. Salary and non-salary expenditures associated with payments inject new money into the local economy and support employment and income in sectors which support construction, primary and secondary education, and the Government sectors.

While direct distributions resulting from the leasing and development of federal minerals within the Pawnee account for only a small portion of total distributions currently received by local governments in Weld County, future development of these minerals is anticipated to significantly increase distributions to surrounding communities.

Non-Market Values

The true value of the PNG is equal to the value of all goods and services it provides society. Generally goods and services are traded in markets where interactions between buyers and sellers determine the price, or value, of a good based on unit prices and the quantities sold. While the natural resources within these grasslands produce a wide range of environmental goods and services, markets in which these environmental products can be bought or sold do not always exist. Some goods, like forage for cattle, can easily be valued because livestock feed can be bought and sold in markets. Other resources on the PNG, like sites of cultural or historic significance, recreational opportunities, ecological processes, and scenic views cannot be bought and sold in traditional markets, which is why these resources are often characterized as non-market goods. Although the public benefits from these goods, they lack value in the traditional sense of market prices often causes these resources to be undervalued.

Non-market values can be broken down into two categories, use and non-use values. While the use of non-market goods often requires consumption of associated market goods, such as food, gas and lodging, the benefits people derive from non-market goods exceed any monetary cost associated with their use. Many non-market use-values exist for natural resources administered by the Pawnee National Grasslands. Some use-values are associated with recreational experiences, while others are associated with aesthetic enjoyment, artistic and spiritual inspiration, and emotional comfort derived from its picturesque landscapes. The wild and scenic landscape of the PNG provides a refuge from the modern world where people can escape and reconnect with the natural world. Opportunities to explore and enjoy the scenic beauty of the natural environment have been known to fill and inspire people with a feeling, an idea, or a creative impulse. Nature has long served as inspiration for a wide range of artistic and cultural expressions, including: film, literature, photography, paintings, sculptures, music and dance, fashion, folklore, national symbols, and even architecture and advertisement (Rudolph de Groot et al. 2005).

Non-use, or passive use, values of a non-market good reflect the value of an asset beyond its current use. These can be described as existence, option and bequest values. Existence values are the amount society is willing to pay to guarantee that an asset simply exists. An existence value for the PNG might be the value of knowing that American shortgrass prairies exist or the value associated with undeveloped scenic landscapes. In addition to implicit existence values, society's willingness to pay to preserve resources for future use attaches additional passive use values. The potential benefits people would receive from future visits to the Pawnee are referred to as option values when future use is expected to occur within the same generation and bequest values when preservation allows future generations to benefit from the resource use. Within the PNG bequest and option values might exist for numerous plant and animal species, wild and scenic landscapes, and recreational trails.

While non-market values may exist for many of the PNG's natural resources, it can be very difficult to quantify use and non-use values. Since the methodologies for measuring these values can be controversial and difficult to apply, non-market goods tend to be undervalued. While it is not feasible to estimate non-market values during the planning process, it is important for forest management to recognize that the true value of forest resources include both market and non-market values so that they can make more informed decisions regarding their use.

3.16.2 Environmental Consequences

The previous sections assessed social and economic conditions and trends. The following section will consider the potential consequences of alternative management scenarios on the social and economic environment.

Methodology and Assumptions

This section discusses how future federal oil and gas leasing and development may affect economic activity in the local economy. The results of this type of analysis are known as *economic impacts* and are reported in terms of the change in local employment, income, and public revenues. As an economic activity analysis, this analysis provides insight as to how future leasing and development of federal minerals may affect the flow of money to local households and businesses. Economic impact analyses do not quantify potential changes in social welfare, so their results cannot be interpreted as economic benefits or costs.

Economic impacts associated with federal mineral leasing and development on the PNG were estimated using IMPLAN Professional Version 3.0 and the Forest Economic Analysis Spreadsheet Tool (FEAST), with 2012 data. IMPLAN is a customizable input-output model which provides a means of examining the flow of economic activity, both between businesses and between businesses and final consumers, within a regional economy. The IMPLAN model is one of the most widely used tools for regional economic analysis because it allows users to easily build custom models which measure net changes in economic activity as a result of a decision, event, or a policy. The resulting mathematical representation allows one to examine how changes in employment or final demand ripple through the local economy, creating indirect and induced effects in sectors which support the oil and gas industry and local household and government spending.

In addition to economic impacts, future oil and gas development on the PNG may also have social consequences that are unlikely to be reflected in traditional economic statistics. Development could affect quality of life as it relates to changes in population, public infrastructure, government services, recreational trends, transportation system, scenic quality, and other social implications of oil and gas development. Potential social impacts are discussed

qualitatively and address how management actions under the alternatives may affect traditional and cultural ties to federal lands within the area of influence.

Assumptions

Potential future development of oil and gas leases might result in impacts to local economies. These impacts could result from changes in tourism, grazing, and other indirect effects from oil and gas development. The following list presents the basic assumptions related to the social and economic analysis of potential impacts resulting from future mineral leasing and development on the Pawnee National Grasslands.

- The analysis of impacts to other resources is based on effects described in the Recreation, and Range and Noxious Weeds sections of this EIS.
- The analysis of revenues associated with livestock grazing on the Pawnee assumes the federal rate for forage will remain constant at \$1.35 per AUM
- The analysis of future oil and gas development on the PNG is based on reasonably foreseeable development on PNG as discussed in section 2. *Alternatives Considered in Detail* and 3.10.2 *Environmental Consequences of Fluid Mineral*.
- Since the timing of future development is unknown, total anticipated wells and production reported in 3.10.2 were assumed to occur evening over the next 30 years (i.e. well or total production ÷ 30 years).
- Proposed management actions under this EIS will only apply to federal surface and sub-surface resources within PNG boundaries. In the case of split estate minerals, leases are subject to applicable Forest Service occupancy stipulations.
- Existing mineral leases are subject to valid and existing rights. Lease terms and stipulations of existing federal leases would not be affected by changes in PNG's management of fluid minerals.
- Federal mineral leases expire after 10 years unless the parcel is incorporated into an existing field through a communitization agreement or one or more producing wells is drilled on the lease parcel. Leases that are held by production do not expire until they are no longer capable of production.
- Because of the Niobrara's large known reserves, and the high anticipated success rate of well pads, none of the existing leases are anticipated to expire over the next 20 plus years.
- Revenues associated with future leasing on the PNG were analyzed based on distributions determined by federal and state statutes.
- Bonus bids for parcels on the PNG are anticipated to be much higher than historical bids. For the analysis of bonus bid associated with new federal leases, an average bonus bid of \$3,000 per acre was used. This estimate was based on expertise provided by fluid minerals specialists at the BLM's Colorado State Office.
- Estimates of the levels of employment and labor income that would be supported by the alternatives are based on projected wells drilled and consequent oil and gas production

(see geology and minerals section for production estimate details) and estimated payments to counties (see previous discussion of county payments).

Effects Common to All Alternatives

Since federal leases are subject to valid and existing rights, exploration and development of fluid minerals on the Pawnee will continue under all alternatives. Future development of the Niobrara shale play is anticipated to increase oil and gas related activities in the study area regardless of Forest Service's management of the PNG. None of the alternatives are anticipated to reduce economic diversity (the number of economic sectors) or increase economic dependency, which occurs when the local economy is dominated by a limited number of industries. Although future mineral development under the alternatives have the potential to affect local businesses and residents, overall contributions of the PNG (i.e. jobs and labor income) to the local economy will remain relatively small and not have a measurable effect on overall economic diversity or dependency within the study area. Future shifts in the emphasis of the local economy will likely occur over the next 2 decades; however, these shifts would not be a consequence of actions proposed in this EIS.

Although overall economic contributions of the Pawnee to local economy account for only a small portion of total employment and income within the three-county analysis area, these contributions may be more important at the local level. Since individual communities may be less economically diverse than the larger regional economy, some communities are likely to be more dependent on oil and gas related activities on the PNG. While effects to economic diversity and dependency at the local area could be greater, these effects are not assessed given a lack of county level information on anticipated oil and gas development. The lack of this information also makes assessment of other effects to quality of life at the local level difficult to assess.

Recreation Related Effects

Demand for recreational experiences on the Pawnee is anticipated to increase as populations along the Front Range continue to grow. All alternatives will continue to support recreation uses discussed above, however, future oil and gas development has the potential to affect the quality and quantity of some outdoor experiences provided by the PNG. While localized changes in recreation access and use could occur, these changes cannot be predicted without having good baseline visitation information and knowing exactly where development will occur and the extent to which substitute opportunities within the analysis area will be available. In addition, drawing conclusions about changes to access based on possible oil and gas development may not be appropriate since site specific information on recreation access and use of substitute recreation areas makes evaluation impractical. Future site specific planning should consider effects on quality of life from changes in access and effects on recreation.

Recreational experiences under all alternatives would continue to contribute to the overall quality of life enjoyed by local residents and stimulate economic activity throughout the local economy. Despite the lack of site specific information, certain dispersed recreation activities such as birding, motorized recreation, and recreational target shooting may be susceptible to change and are of concern given their importance within the analysis area. As discussed in the recreation section, the extent to which the PNG increased surface disturbances and commercial use of low-density dispersed recreational sites may cause recreationists to become displaced. While future oil and gas development has the potential to adversely affect recreational experiences provided by the Pawnee, it is not clear whether this development will cause shifts in the types of activities recreationists travel to the PNG to participate in or have a net effect on overall recreational visits to the PNG. Net changes in visitation to the Pawnee will likely affect the amount of travel related dollars attracted and retained within the local economy. As discussed in the existing conditions, recreationists traveling to the PNG spend money on food, gas, lodging, and other travel related expenses in surrounding communities which stimulate employment and income in numerous industrial sectors that support the travel and tourism industry. Although the level of employment and income directly attributed to visitation to the amendment area could not be estimated, these economic contributions are an important role in providing employment and income opportunities to residents in rural communities surrounding the Pawnee..

Livestock Grazing Related Effects

As discussed in the range section, future oil and gas development has the potential to affect permitted grazing levels on the Pawnee, the maximum acres of man-made surface disturbance would only account for approximately 0.5 % of all acres authorized for grazing. This level of disturbance is insignificant when applied across the whole PNG and would not affect the carrying capacity of the range unless those acres were concentrated within one grazing unit so that an excess of 20% of the allotment was removed from grazing when combined with other effects. Preference limits under the alternatives will continue to support recent billed use levels. Although the Pawnee's grazing potential has been estimated to be more than 48,000 AUMs a year, grazing is often restricted below its full potential because of factors such as drought, rangeland conditions, changes in active permit holders, financial limitations on operators and market conditions. Future billed use on the PNG will fluctuate from year to year, but these fluctuations are more likely to result from changes in the natural and economic environment than from oil and gas related surface disturbances.

In terms of local area contributions from Forest Service supplied forage, permitted use levels of grazing on the Pawnee would continue to support 102 total jobs and approximately \$1.8 million in local labor income (including direct, indirect and induced wages and proprietor's income) on an average annual basis. Public revenues associated with the redistribution of federal grazing

fees will support additional employment and income. Under the alternatives grazing associations and individual permit holders would continue to pay federal grazing fees. In accordance with federal and state statutes, 25 percent of federal revenue from livestock grazing on Forest Service lands is distributed back to Colorado to fund public schools and roads in the county when revenue was generated (16 U.S. Code § 500).

Since annual permitted use levels will not change under the alternatives, livestock grazing on the Pawnee will continue to contribute to the preservation of ranching heritage and community values associated with livestock production. While drilling activities may have short-term disparate effects on individual permit holders, access to federal forage on PNG allotments will continue to support traditional uses and values associated with the ranching way of life. Continued access to federal forage will reinforce the longstanding bonds between local ranching families and these rangelands.

Social Impacts Associated Oil and Gas Development

The combination of horizontal drilling and multi-stage hydraulic fracturing (or “fracking”) has drastically increased the recoverability of sub-surface minerals surrounding the Pawnee. Oil and gas development on the PNG is anticipated to increase under all alternatives over the next 2 decades. While the environmental effects to soils, water, and air quality have been discussed in previous sections of this EIS, Weld County’s unavoidable shale boom is likely to impose social costs which threaten human health and safety and undermine the quality of life in many of the area’s rural communities.

Recent shale booms in other parts of the country have caused changes in rural traffic patterns and increased commercial use of roads by heavy trucks because of the need to deliver equipment, supplies and workers to drilling sites. Previous studies have found that the truck traffic needed to deliver water to a single fracking well causes as much damage to local roads as nearly 3.5 million car trips (Randall, 2010). Road damage caused by increased commercial use in other shale regions of the U.S. has cost states millions. Repairs associated with increased truck traffic in the Barnett Shale region of Texas was estimated to cost Texas \$40 million, while an Executive Summary in Pennsylvania estimated that damaged roads in the Marcellus Shale region needed \$265 million in repairs in 2010 (Dutzik et. al 2012). Increased road usage in areas experiencing energy booms strains the capacity of rural roadways and contributes to rising truck and automobile accidents (Petkova et. al 2009). While increased truck volume may not cause traffic congestion by itself, increased road use often occurs in rural areas where traffic data are not available and additional truck traffic, noise, and dust may be easily noticed. Oil and gas related congestion and traffic accidents have been recognized as a growing socio-economic challenge which pose significant hazards to local residents (Dutzik et. al 2012).

The oil and gas industry is characterized as having a highly transitory workforce. Since most the labor is involved in the early stages of development while wells are being drilled and equipped, small communities often experience large influxes of temporary residents during energy booms. The relatively overnight flood of non-local workers places additional strain on existing infrastructure and public services. Boomtowns regularly experience housing shortages which drive up the local housing costs,

while emergency and public health services are struggle to meet additional demand (Lawrie et. al 2011, Headwaters Economics 2012). Oil booms have also been noted to create more social unrest in previously tranquil towns. Comparisons of pre-boom statistics to those experienced during high periods of shale development indicate that there is a strong correlation between increased mineral development and increases in alcohol-related crimes, traffic accidents, emergency room visits and sexually transmitted infections (Dutzik et. al 2012).

Extraction of oil and gas in Weld County is anticipated to increase regardless of management actions proposed in this EIS. Since negative social effects have been strongly linked to increases in oil and gas related activities, communities surrounding the Pawnee will likely incur social costs under all alternatives. The extent to which these social costs will adversely affect the quality of life of residents who live and work in Larimer, Logan, and Weld counties will depend on the proximity to routes leading in and out of the Pawnee and the number of transient oil and gas workers which take up temporary residency in the surrounding area. At the local level, social costs will likely be highest in communities closest to the PNG.

Alternative 1

Alternative 1 is the no new leasing alternative. Under this alternative, Forest Service would prohibit any additional leasing of federal minerals on the Pawnee. Since existing leases are subject to valid and existing rights, oil and gas related activities associated with federal minerals on the PNG are not only anticipated to continue over the next 20 to 30 years, but will increase as current leases become more developed. Other than federal minerals accessible from existing leases, all future development of the Niobrara would be pushed onto parcels where sub-surface minerals are privately or state owned. The prohibition on future federal mineral leasing under this alternative will have direct and indirect effects on the social and economic environment within the three-county study area. Social and economic impacts associated with the no leasing alternative will result from changes in oil and gas development, and public revenues. As discussed above in the Effects Common to All Alternative sections, future oil and gas development on the Pawnee is not anticipated to have measurable social or economic impacts associated with livestock grazing activities on the PNG.

Recreation

The no new leasing alternative is anticipated to have a negligible effect on the Pawnee's recreational resource. Since future oil and gas development on the PNG would be limited to existing federal leases, recreation management would continue under current guidance and policy and existing recreation opportunities in the study area would be maintained. People would continue to recreate on public lands as they have done in the past. Recreational experiences supported by Forest Service lands within the Pawnee would continue to contribute to the overall quality of life enjoyed by local residents and stimulate economic activity throughout the local economy. As discussed in the existing conditions, recreationists traveling to these areas spend money in the local economy and stimulate employment and income in numerous industrial sectors that support the travel and tourism industry. Although the level of employment and income directly attributed to visitation to the amendment area could not be estimated, the magnitude and importance of these economic contributions to rural communities surrounding the Pawnee are not anticipated to change under the no new leasing alternative.

Issuance of recreation special uses and lands authorizations would continue using Forest Plan direction, interim guidance, and existing policy and direction. Since this alternative is not anticipated to effect the quality or quantity of recreational experiences supported by the PNG, this alternative would not result in impacts to revenue of commercial outfitters or managing agencies attributable to Forest Service SUAs.

Oil and Gas Development

Alternative 1, the No New Leasing Alternative, is the most prohibitive of future oil and gas development on the Pawnee. Under this alternative, all unleased federal minerals that are available for leasing in the 1997 Forest Plan ROD (approximately 146,367 acres) would be withdrawn from leasing consideration. All federal oil and gas resources that are not leased at the time this EIS is completed will be bypassed and lost from production. Approximately 178 million barrels of oil and 356 MCF of gas will be produced from federal minerals under the no new leasing alternative. Since federal minerals would be bypassed, approximately 5.5 billion barrels of oil in unleased federal minerals and 2 billion barrels of juxtaposed private and state oil would be lost from production. Over the life of this field, average annual production from federal minerals below the PNG is estimated to be about 5.9 million bbls of oil and nearly 11.9 million MCF of natural gas. The extraction of these minerals is estimated to generate more than \$72 million in federal royalties and support a total of nearly 500 direct, indirect, and induced jobs and \$30.1 million in local income on annual average. While drilling activities on existing leases are anticipated to support an additional 229 jobs and \$12.7 million in local income on annual average.

Although no new federal leases would be offered under Alternative 1, it is very unlikely that federal mineral leasing would decline because of the high success rates of extracting the large continuous reserves of the Niobrara. Under this alternative, no federal revenue would be generated from new lease bonus bids and annual rent revenues. On annual average existing federal leases on the PNG are anticipated to generate approximately \$45,000 in federal revenue from annual rents, but these revenues are anticipated to fall to zero as development of currently non-producing federal leases results in oil and gas production. Once held by production, leases are no longer subject to rental payments.

Since approximately 5.5 billion barrels of oil in unleased federal minerals and 2 billion barrels of juxtaposed private and state oil will be bypassed and lost from production under the no new leasing alternative, the loss of this production potential will hamper future local job creation. On annual average, the prohibition on the development of federal mineral estates reduces total production (i.e. from federal, state, and private minerals) associated with the Niobrara by approximately 250 million bbls and 500 million MCF of gas. This annual loss of production potential reduces the number of economic opportunities supported by the oil and gas industry.

Public Revenues

Use of natural resources managed as part of Pawnee National Grasslands generates federal, state, and county revenues. The two primary revenue generating resources on the PNG include range and fluid minerals (i.e. oil and gas). Under Alternative 1 livestock grazing and oil and gas development on the Pawnee are estimated to generate approximately \$72.8 million in federal

revenue and \$123 million in state revenue for Colorado (Table 84). The State of Colorado uses these revenues to fund public schools and infrastructure projects, and to mitigate local impacts of oil and gas development in producing counties (Figures 5 & 6).

Based on current federal grazing fees and average annual forage permitted on the Pawnee, the PNG's range program generates about \$65,900 in federal revenue annually. In accordance with federal and state statutes, a portion of these monies are distributed back to the counties in which they were collected. As discussed in the Livestock Grazing Related Effects section of Effects Common to All Alternatives, 25 percent of federal revenue from livestock grazing on Forest Service lands is distributed back to Colorado to fund public schools and roads in the county when revenue was generated (16 U.S. Code § 500). Nearly \$16,500 of that is distributed back to Weld County to help fund public schools and road repairs.

Table 84 Anticipated Public Revenues Generated Under Alternative 1

Federal Revenues	
Grazing Fees	\$ 65,908
Bonus Bids	\$ -
Rents	\$ 45,395
Royalties	\$ 72,787,167
Colorado State Revenues	
Colorado Severance Tax	\$ 87,344,600
Distribution of Non-Bonus Bid Revenues	\$ 35,687,955.36
Distribution of Bonus Bid Revenue	\$ -
Weld County Revenues	
Distribution of Fed Grazing Fees	\$ 16,477
Distribution of State Severance Tax	\$ 1,310,169
Distribution of Non-Bonus Bid Revenues	\$ 7,137,591
Local Ad Valorem Taxes	\$ 46,583,787

Colorado and Weld County collect a large amount of revenue from oil and gas development on the Pawnee. In addition to regular corporate taxes paid by oil and gas companies operating out Colorado, oil and gas producers are required to pay property and production taxes. As discussed in the affected environment, Weld County assesses an Ad Valorem tax on the actual value of oil and gas produced within the county. This Ad Valorem tax is a property tax imposed on local production and capital investments to ensure that revenues stay in the local communities that have mineral development operations. Based on estimates of average annual production, an effective tax rate of 8 percent, and 2012 Colorado wellhead prices for crude oil and natural gas, PNG production under Alternative 1 will generate approximately \$46.5 million in Valorem County tax revenue on annual average.

In addition to revenues from county taxes, Weld County receives a portion of federal revenues from the leasing and development of federal minerals within the PNG. As explained in the Federal Payments to Counties section of the Affected Environment, 49 percent of federal

revenues collected from the leasing and development of federal minerals is returned to the state are used to fund public schools, water projects, infrastructure improvements, and to mitigate local impacts of oil and gas development in producing counties (figure 6). Under Alternative 1, Weld County is expected to receive approximately \$7 million in public revenues from the redistribution of federal non-bonus (i.e. rents and royalties) revenue.

The State of Colorado also returns a portion of state severance taxes back to oil and gas producing counties (figure 5). Of the \$8.7 million in state severance taxes estimated to be collected on annual average from PNG production under Alternative 1, 50 percent is allocated to the Department of Local Affairs to fund local grants (70 percent) and direct distributions back to producing counties (30 percent). Direct distributions back to Weld County from state Severance Taxes on PNG production are estimated to exceed \$1.3 on annual average under Alternative 1.

As the county revenues are used to salary and non-salary expenditures associated with funding public school, road construction and repairs, and to provide public services (including police and other emergency services). These revenues create a ripple effect which stimulates additional economic activities which provide these sectors with inputs and in sectors which support household spending. On annual average, county revenues from oil and gas development under Alternative 1 is anticipated to support approximately 750 total local jobs and \$34.2 million in local wages and proprietor's income.

Alternatives 2

Alternative 2 is considered the no action alternative since management of Pawnee's sub-surface minerals would continue under current guidance and policy. Under this alternative, all unleased federal minerals would continue to be administratively available for leasing with stipulations outlined in the 1997 Forest Plan upon further NEPA analysis. Future federal mineral leasing under these alternatives will have direct and indirect effects on the social and economic environment within the three-county study area. Social and economic impacts associated with Alternatives 2 will result from changes in oil and gas development and public revenues. As discussed above in the Effects Common to All Alternative sections, future oil and gas development on the Pawnee is not anticipated to have measurable social or economic impacts associated with livestock grazing activities on the PNG.

Recreation

As discussed in the Recreation section of this EIS, anticipated oil and gas development under Alternative 2 will adversely affect the quality and quantity of some recreational experiences on the Pawnee. Although the 1997 Forest Plan includes provisions to protect RNA's, SIA's, and developed recreation sites from mineral development, future oil and gas activities under this alternative threatens motorized recreation, bird watching, recreational shooting on the PNG. Since future oil and gas development on the PNG under standard stipulations would increase surface disturbances and commercial traffic in areas where dispersed recreation occurs, leasing and development under Alternative 2 has the potential to displace a large number of recreationists. While localized changes in recreation access could result from the inability to use public lands as people had in the past, these changes cannot be predicted without knowing

exactly where development will occur and the extent to which substitute opportunities on the Pawnee will continue to be available.

Recreational experiences supported by Forest Service lands within the Pawnee would continue to contribute to the overall quality of life enjoyed by local residents and stimulate economic activity throughout the local economy. As discussed in the existing conditions, recreationists traveling to these areas spend money in the local economy and stimulate employment and income in numerous industrial sectors that support the travel and tourism industry. While future oil and gas development may have adverse effects on outdoor recreation under Alternative 2, it is not clear whether this development will cause shifts in the types of activities recreationists travel to the PNG to participate in or have a net effect on overall recreational visits to the PNG. Although the level of employment and income directly attributed to visitation to the Pawnee could not be estimated, oil and gas development under Alternative 2 may reduce future recreation related economic activity in rural communities surrounding the PNG.

Issuance of recreation special uses and lands authorizations would continue using Forest Plan direction, interim guidance, and existing policy and direction. Since six of the Special Use Permits are held by outfitters providing guided bird-watching tours, and development under the no action alternative may adversely affect the quality and quantity of birding experiences, oil and gas activities under this alternative will likely affect future SUP's. If oil and gas development does significantly alter bird watching experiences on the Pawnee, special-use permit holders for guided birding tours may experience a decline in the demand for their services, reducing local commercial revenues and recreation related expenses associated with birding.

Oil and Gas Development

Under Alternative 2 all unleased federal minerals that are available for leasing in the 1997 Forest Plan ROD (approximately 146,367 acres) would continue to be available to leasing and development upon completion of subsequent NEPA analysis. Any new federal leases authorized on the Pawnee would be subject to lease stipulations in the 1997 Forest Plan and may include no surface occupancy and timing restrictions. Since valid and existing rights are grandfathered in, this alternative will have no effect on existing federal mineral leases on the Pawnee. Approximately 590 million barrels of oil and 1.1 billion MCF of gas will be produced from federal minerals under the no action alternative over the next 20 to 30 years. Over the life of this field, average annual production from federal minerals below the PNG is estimated to be about 19.6 million bbls of oil and nearly 39.3 million MCF of natural gas. The extraction of these minerals is estimated to generate more than \$241 million in federal royalties and support more than 1,600 direct, indirect, and induced jobs and \$99.7 million in local income on annual average. While drilling activities associated with new and existing leases are anticipated to support an additional 208 jobs and \$11.6 million in local income on annual average.

It is anticipated that all 100,329 acres of unleased federal minerals on the PNG will be leased over the next 10 to 20 years. Since all the federal minerals are believed to be accessible by drilling locations either on leased lands or from off-site locations with horizontal wells, and drilling success rates using horizontal drilling and fracking practices in this area are expected to approach 100 percent, there is tremendous industry interest in leasing these federal minerals. Based on known geology, private sales, the limited number of parcels available, and

the critical location of the PNG, it is estimated that new leases will command bonus bids ranging between \$50 and \$9,000 per acre. It is estimated that future parcels on the Pawnee will earn \$3,000 per acre on average, with bonus bids in the eastern portion of the PNG driving up per acre averages. Under this alternative, bonus bids for newly leased federal minerals are estimated to generate nearly \$970,000 in revenue from leasing federal minerals on the Pawnee. In addition to one-time bonus bids, the federal government will earn annual rents on leases that have not started producing oil or gas, or been incorporated into communitization agreement. On annual average, the combination of new and existing federal leases on the PNG is anticipated to generate more than \$220,000 in federal rent revenue annually

Public Revenues

Use of natural resources managed as part of Pawnee National Grasslands generates federal, state, and county revenues. The two primary revenue generating resources on the PNG include range and fluid minerals (i.e. oil and gas). Under Alternative 2 livestock grazing and oil and gas development on the Pawnee are estimated to generate approximately \$242 million in federal revenue and \$408 million in state revenue for Colorado (Table 85). The State of Colorado uses these revenues to fund public schools and infrastructure projects, and to mitigate local impacts of oil and gas development in producing counties (Figures 68 & 69).

Based on current federal grazing fees and average annual forage permitted on the Pawnee, the PNG's range program generates about \$65,900 in federal revenue annually. In accordance with federal and state statutes, a portion of these monies are distributed back to the counties in which they were collected. As discussed in the Livestock Grazing Related Effects section of Effects Common to All Alternatives, 25 percent of federal revenue from livestock grazing on Forest Service lands is distributed back to Colorado to fund public schools and roads in the county when revenue was generated (16 U.S. Code § 500). Nearly \$16,500 of that is distributed back to Weld County to help fund public schools and road repairs.

Table 85 Anticipated Public Revenues Generated Under Alternative 2

Federal Revenues	
Grazing Fees	\$ 65,908
Bonus Bids	\$ 969,579
Rents	\$ 220,971
Royalties	\$ 241,260,833
Colorado State Revenues	
Colorado Severance Tax	\$ 289,513,000
Distribution of Non-Bonus Bid Revenues	\$ 118,326,084.15
Distribution of Bonus Bid Revenue	\$ 475,093
Weld County Revenues	
Distribution of Fed Grazing Fees	\$ 16,477
Distribution of State Severance Tax	\$ 4,342,695
Distribution of Non-Bonus Bid Revenues	\$ 23,665,217
Local Ad Valorem Taxes	\$ 154,406,933

Colorado and Weld County collect a large amount of revenue from oil and gas development on the Pawnee. In addition to regular corporate taxes paid by oil and gas companies operating out Colorado, oil and gas producers are required to pay property and production taxes. As discussed in the affected environment, Weld County assesses an Ad Valorem tax on the actual value of oil and gas produced within the county. This Ad Valorem tax is a property tax imposed on local production and capital investments to ensure that revenues stay in the local communities that have mineral development operations. Based on estimates of average annual production, an effective tax rate of 8 percent, and 2012 Colorado wellhead prices for crude oil and natural gas, PNG production under Alternative 2 will generate approximately \$154 million in Valorem County tax revenue on annual average.

In addition to revenues from county taxes, Weld County receives a portion of federal revenues from the leasing and development of federal minerals within the PNG. As explained in the Federal Payments to Counties section of the Affected Environment, 49 percent of federal revenues collected from the leasing and development of federal minerals is returned to the state are used to fund public schools, water projects, infrastructure improvements, and to mitigate local impacts of oil and gas development in producing counties (figure 6). Under Alternative 2, Weld County is expected to receive approximately \$23 million in public revenues from the redistribution of federal non-bonus (i.e. rents and royalties) revenue.

The State of Colorado also returns a portion of state severance taxes back to oil and gas producing counties (figure 5). Of the \$289 million in state severance taxes estimated to be collected on annual average from PNG production under Alternative 3, 50 percent is allocated to the Department of Local Affairs to fund local grants (70 percent) and direct distributions back to producing counties (30 percent). Direct distributions back to Weld County from state Severance Taxes on PNG production are estimated to exceed \$4.3 on annual average under Alternative 2.

As the county revenues are used to salary and non-salary expenditures associated with funding public school, road construction and repairs, and to provide public services (including police and other emergency services). These revenues create a ripple effect which stimulates additional economic activities which provide these sectors with inputs and in sectors which support household spending. On annual average, county revenues from oil and gas development under Alternative 2 is anticipated to support approximately 2,492 total local jobs and \$113.5 million in local wages and proprietor's income.

Alternative 3

Similar to Alternative 2, 100,329 acres of federal minerals would be administratively available for leasing on the Pawnee under Alternative 3. Under this alternative, all new federal mineral leases within the PNG would be subject to No Surface Occupancy lease stipulations. Future

federal mineral leasing under these alternatives will have direct and indirect effects on the social and economic environment within the three-county study area. Social and economic impacts associated with the NSO Alternative will result from changes in oil and gas development and public revenues. As discussed above in the Effects Common to All Alternative sections, future oil and gas development on the Pawnee is not anticipated to have measurable social or economic impacts associated with livestock grazing activities on the PNG.

Recreation

Leasing with NSO stipulations is anticipated to have a negligible effect on the Pawnee's recreational resource. Since future oil and gas development on the PNG would not increase surface disturbances under this alternative, recreation management would continue under current guidance and policy and existing recreation opportunities in the study area would be maintained. People would continue to recreate on public lands as they have done in the past. Recreational experiences supported by Forest Service lands within the Pawnee would continue to contribute to the overall quality of life enjoyed by local residents and stimulate economic activity throughout the local economy. As discussed in the existing conditions, recreationists traveling to these areas spend money in the local economy and stimulate employment and income in numerous industrial sectors that support the travel and tourism industry. Although the level of employment and income directly attributed to visitation to the amendment area could not be estimated, the magnitude and importance of these economic contributions to rural communities surrounding the Pawnee are not anticipated to change under the no new leasing alternative.

Issuance of recreation special uses and lands authorizations would continue using Forest Plan direction, interim guidance, and existing policy and direction. Since this alternative is not anticipated to effect the quality or quantity of recreational experiences supported by the PNG, this alternative would not result in impacts to revenue of commercial outfitters or managing agencies attributable to Forest Service SUAs.

Oil and Gas Development

Under Alternative 3, all unleased federal minerals that are available for leasing in the 1997 Forest Plan ROD (approximately 146,367 acres) would continue to be available to leasing and development upon completion of subsequent NEPA analysis. Any new federal leases authorized on the Pawnee would be subject to no surface occupancy restrictions, making federal minerals only accessible thru off-site locations with horizontal wells. This type of restricted access would impose additional costs on the oil and gas industry. Since producers would be forced to also lease private or state lands in order to develop federal mineral rights, industry costs associated with producing oil and gas from the PNG would be much higher under this alternative. Since valid and existing rights are grandfathered in, NSO stipulations would have no effect on existing federal mineral leases on the Pawnee. Similar to Alternative 2, approximately 590 million barrels of oil and 1.1 billion MCF of gas would be produced from federal minerals under Alternative 3 over the next 20 to 30 years. Over the life of this field, average annual production from federal minerals below the PNG is estimated to be about 19.6 million bbls of oil and nearly 39.3 million MCF of natural gas. The extraction of these minerals is estimated to generate more than \$241 million in federal royalties and support more than 1,600 direct, indirect, and induced jobs and \$99.7 million in local income on annual average.

While there would be no drilling activities associated with new federal leases under this alternative, new wells are still anticipated to be drilled on existing leases and on neighboring private and state lands in order to develop FS administered minerals. The number of new wells projected under the Alternative 3 would be similar to that anticipated under Alternative 2. Economic activity associated with oil and gas drilling would be estimated to support an additional 208 jobs and \$11.6 million in local income on annual average.

It is anticipated that all 100,329 acres of unleased federal minerals on the PNG will be leased over the next 10 to 20 years. Since all the federal minerals are believed to be accessible by drilling locations either on leased lands or from off-site locations with horizontal wells, and drilling success rates using horizontal drilling and fracking practices in this area are expected to approach 100 percent, there is tremendous industry interest in leasing these federal minerals. While the same number of federal minerals are anticipated to be leased under Alternative 3 as under Alternative 2, federal bonus bids for parcels with NSO stipulations may be lower than those anticipated under Alternative 2 since mineral oil companies would have to pay additional leasing fees for adjacent private and state lands in order to develop federal minerals. Since there is a lot of uncertainty as to what extent NSO restrictions would have an effect on future bonus bids, the estimated that future per acre bonus bid of \$3,000 may be a better reflection of an upper bound for bonus bids on NSO mineral leases. Under this assumption, bonus bids for newly leased federal minerals with NSO restrictions may generate up to \$969,579 in revenue from leasing federal minerals on the Pawnee. In addition to one-time bonus bids, the federal government will earn annual rents on leases that have not started producing oil or gas, or been incorporated into communitization agreement. On annual average, the combination of new and existing federal leases on the PNG is anticipated to generate more than \$220,000 in federal rent revenue annually.

Public Revenues

Use of natural resources managed as part of Pawnee National Grasslands generates federal, state, and county revenues. The two primary revenue generating resources on the PNG include range and fluid minerals (i.e. oil and gas). Under Alternative 3 livestock grazing and oil and gas development on the Pawnee are estimated to generate approximately \$242 million in federal revenue and \$408 million in state revenue for Colorado (Table 86). The State of Colorado uses these revenues to fund public schools and infrastructure projects, and to mitigate local impacts of oil and gas development in producing counties (Figures 68 & 69).

Based on current federal grazing fees and average annual forage permitted on the Pawnee, the PNG's range program generates about \$65,900 in federal revenue annually. In accordance with federal and state statutes, a portion of these monies are distributed back to the counties in which they were collected. As discussed in the Livestock Grazing Related Effects section of Effects Common to All Alternatives, 25 percent of federal revenue from livestock grazing on Forest Service lands is distributed back to Colorado to fund public schools and roads in the county when revenue was generated (16 U.S. Code § 500). Nearly \$16,500 of that is distributed back to Weld County to help fund public schools and road repairs.

Table 86 Anticipated Public Revenues Generated Under Alternative 3

Federal Revenues	
Grazing Fees	\$ 65,908
Bonus Bids	\$ 969,579
Rents	\$ 220,971
Royalties	\$ 241,260,833
Colorado State Revenues	
Colorado Severance Tax	\$ 289,513,000
Distribution of Non-Bonus Bid Revenues	\$ 118,326,084.15
Distribution of Bonus Bid Revenue	\$ 475,093
Weld County Revenues	
Distribution of Fed Grazing Fees	\$ 16,477
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Distribution of Non-Bonus Bid Revenues	\$ 23,665,217
Local Ad Valorem Taxes	\$ 154,406,933

Colorado and Weld County collect a large amount of revenue from oil and gas development on the Pawnee. In addition to regular corporate taxes paid by oil and gas companies operating out Colorado, oil and gas producers are required to pay property and production taxes. As discussed in the affected environment, Weld County assesses an Ad Valorem tax on the actual value of oil and gas produced within the county. This Ad Valorem tax is a property tax imposed on local production and capital investments to ensure that revenues stay in the local communities that have mineral development operations. Based on estimates of average annual production, an effective tax rate of 8 percent, and 2012 Colorado wellhead prices for crude oil and natural gas, PNG production under Alternative 3 will generate approximately \$154 million in Valorem County tax revenue on annual average. Since producers would have to lease additional lands and may end up producing a combination of federal, state, and private minerals, leasees would likely be liable for additional Ad Valorem taxes on non-federal production under this alternative.

In addition to revenues from county taxes, Weld County receives a portion of federal revenues from the leasing and development of federal minerals within the PNG. As explained in the Federal Payments to Counties section of the Affected Environment, 49 percent of federal revenues collected from the leasing and development of federal minerals is returned to the state are used to fund public schools, water projects, infrastructure improvements, and to mitigate local impacts of oil and gas development in producing counties (figure 6). Under Alternative 3, Weld County is expected to receive approximately \$23 million in public revenues from the redistribution of federal non-bonus (i.e. rents and royalties) revenue.

The State of Colorado also returns a portion of state severance taxes back to oil and gas producing counties (figure 5). Of the \$289 million in state severance taxes estimated to be collected on annual average from PNG production under Alternative 3, 50 percent is allocated to the Department of Local Affairs to fund local grants (70 percent) and direct distributions back to producing counties (30 percent). Direct distributions back to Weld County from state

Severance Taxes on PNG production are estimated to exceed \$4.3 on annual average under Alternative 3.

As the county revenues are used to salary and non-salary expenditures associated with funding public school, road construction and repairs, and to provide public services (including police and other emergency services). These revenues create a ripple effect which stimulates additional economic activities which provide these sectors with inputs and in sectors which support household spending. On annual average, county revenues from oil and gas development under Alternative 3 is anticipated to support approximately 2,492 total local jobs and \$113.5 million in local wages and proprietor's income.

Chapter 4-Response to Comments

Approximately 2,500 letters were received and considered during the DEIS comment period. Comment statements were identified from the letters and the IDT provided responses to comments. In general, comments focused on air analysis, leasing procedures, alternatives, and other analysis in the DEIS.

Leasing Procedure Comments

(1) **Comment**-Some commenters questioned why a NSO stipulation will not apply to Forest Service lands with private mineral estate.

Response-Forest Service authority to determine stipulations is limited to federally owned minerals and federal leases on National Forest System lands. Because leasing private mineral estate is not federally owned and does not require a federal lease, the stipulation determinations in this leasing analysis will not apply.

On the PNG, there is approximately 46,000 acres of private mineral estate (Forest Service owned surface estate and private mineral estate). The Forest Plan includes direction for surface management of private mineral estate. It directs that surface management of private mineral estate will be negotiated with the owner and operator to be as close as possible to the standards used for federal minerals; however, prohibiting development is not an alternative.

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While the Forest Plan directs negotiations take place with the owner and operator for surface use to be as close as possible to that on federal minerals, the outcome is not certain. As a result, the FEIS discloses impacts based on the assumption that there is potential for oil and gas development (wells, well pads, roads, or pipelines) on private mineral estate lands and that it is not certain that any stipulations determined in a ROD will apply.

⁵⁴ See Forest Plan pg. 16.

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- (2) **Comment**-Some commenters requested clarification on what activities will be prohibited under the NSO Alternative.

Response-The NSO Alternative will prohibit locating wells and well pads on the leasehold. Because wells and well pads will not be located on the leaseholds, there will be no surface disturbance related to development of the lease. For this reason, the FEIS assumes that under the No Leasing Alternative and NSO Alternative zero acres of surface disturbance from developing federal leases on the PNG.

However, a leasing stipulation is only applicable to the leaseholder. The Forest Service may authorize surface occupancy under special use permits or conduct other ground disturbing activities unrelated to development of the federal lease. For example, the NSO stipulation will not prohibit permits for recreation events, grazing permits, pipeline, utility, or road permits. Decisions on special use permits are subject to NEPA procedures and proposals must undergo screening and evaluation pursuant to 36 CFR 251 Subpart B. In addition, NSO stipulation does not prohibit the Forest Service from conducting ground disturbing activities; such as, building a shooting range or mounting interpretive signs.

- (3) **Comment**-Some commenters requested that the Forest Service identify specific exception, waiver, and modification criteria. Commenters recommended wording similar to that used in the Northern San Juan Basin Coal Bed Methane Project Record of Decision.

Response-36 CFR 228.104 describes the procedures the Forest Service follows to modify, waive, or grant exceptions to lease stipulations. It requires that any request to modify, waive, or grant exceptions to lease stipulations comply with the NEPA. It also includes specific determinations the Forest Service must make before any request is granted (see FEIS pp. 7-8).

The NSO stipulation includes the following language regarding request to modify, waive, or grant exceptions:

Waivers, exceptions, or modifications will be considered in accordance with the direction provided in the Forest plan, 36 CFR 228.104, and other applicable regulations and policies. BLM may not grant any waiver, exception, or modification to this stipulation without Forest Service consent under 36 CFR 228.104.

This language is substantially similar to that used in the Northern San Juan Basin Coal Bed Methane Project Record of Decision. However, it clarifies that the BLM must receive Forest Service consent before they can grant any request.

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- (4) **Comment**-Some commenters requested the FEIS include a discussion regarding future NEPA obligations and decisions for oil and gas development.

Response-The FEIS includes a discussion of the staged decision making process for federal oil and gas leasing and development (see FEIS pp. 2-7).

- (5) **Comment**-Some commenters requested the FEIS describe the RFD. They felt it was important to disclose that the RFD is an “analytic tool” and does not represent a “cap” on development.

Response-The FEIS uses the RFD as an analytic tool to forecast possible environmental impacts. It does not hold out the projection in the RFD as a substantive limit on the number of wells.

- (6) **Comment**-Some commenters requested that the FEIS include a discussion of COGCC rules regarding casings.

Response-The COGCC rules and regulations include multiple requirements for well casings⁵⁵ (e.g. COGCC Rules and Regulation 317). The intent of these regulations is to ensure that casings function as intended and protect groundwater resources. While the FEIS does not catalog all of COGCC’s requirements for casing, it does note these requirements exist (see FEIS pg. 50).

Alternatives Comments

- (7) **Comment**-Some commenters felt the range of alternatives was not adequate and submitted additional alternatives to be considered in detail. These alternatives included: (1) an alternative allowing surface occupancy with “updated” stipulations; (2) an alternative that designates portions of the PNG as unavailable for leasing and portions subject to an NSO stipulation; (3) an alternative that adds additional resource based stipulations to the NSO alternative; (4) an alternative that prohibits hydraulic fracturing on the PNG and within 3 miles of its borders; and (5) an alternative with two separate leasing decisions—one for the east side and one for the west side of the PNG.

Response-The FEIS analyzes three alternatives in detail: Alternative 1-No Leasing; Alternative 2-No Action; and Alternative 3-Leasing with NSO (see FEIS Ch. 2). The DEIS also considered two additional alternatives—Leasing under SLTs and Leasing with

⁵⁵ Colorado Oil and Gas Commission Rules and Regulations are available at: <http://cogcc.state.co.us/>

Additional Resource Stipulations—but dismissed these alternatives from detailed analysis (See DEIS pg. 31-32).

The IDT also examined the five alternatives submitted during the comment period for the DEIS, but these alternatives were dismissed from detailed analysis. A description of these alternatives and the reasons why they were dismissed is included in the FEIS on pp. 30-32.

- (8) **Comment**-Some commenters did not agree with the FEIS's conclusion that No Leasing will cause more surface disturbance, wells, and well pads than leasing. They felt that the No Leasing Alternative and NSO Alternative had similar environmental impacts and would prefer the Forest Service select the No Leasing Alternative.

Response-A section was added to the FEIS to explain why the No Leasing Alternative is expected to result in more wells, well pads, and surface disturbance outside of the PNG than the NSO Alternative (see FEIS pp. 41-48). In short, the analysis examined four townships on the PNG and compared surface disturbance, wells, and well pads under the No Leasing and NSO Alternatives. While both alternatives will not have any surface disturbance on the PNG, the analysis shows between 10% and 50% more surface disturbance on adjacent lands under the No Leasing Alternative. Therefore, while the direct environmental impacts to the PNG are similar under the No Leasing and NSO Alternatives; the No Leasing Alternative will have greater impacts on adjacent lands.

- (9) **Comment**-Some commenters felt that FEIS incorrectly states that the No Leasing Alternative and NSO Alternative will have zero acres of surface disturbance.

Response-The FEIS concludes that there will be zero acres of surface disturbance on the unleased portion of the PNG under the No Leasing and NSO Alternatives because surface occupancy to develop the oil and gas lease will be prohibited (see FEIS pp. 20-21 and 26-27). The FEIS acknowledges that under these alternatives surface disturbance may occur on adjacent lands, private mineral estate, and existing leases (see FEIS pp. 19, 29, and 49).

Air Analysis Comments

- (10) **Comment**-Some commenters felt that the FEIS should include an analysis of the social cost of carbon.

Response-The social cost of carbon protocol (SCC) was developed by an Interagency Working Group (IWG), including the Environmental Protection Agency (EPA) and others, for use in cost-benefit analyses of proposed regulations that could impact cumulative global

emissions (Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866, available at: <http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf>). The SCC is used to estimate the monetized damages associated with an incremental increase in carbon emissions in a given year. It includes (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change. The SCC was developed to assist agencies in meeting Executive Order (EO) 12866's requirement to assess costs and benefits during the development of regulations.

Uncertainty of production rates, volumes, and end uses from the proposed action and alternatives would seriously limit application of the SCC protocol. The Agency does not know how quickly those resources would be developed; whether the fuel would be used in vehicles, power plants, or other consumptive use with varying emission rates; or what changes in technology or climate affecting end-uses may occur. The speculative nature and high variability of such an analysis would be of little use in making a leasing availability decision and subsequent determination of whether specific parcels of NFS land should be leased for oil and gas development.

EO 12866 requires cost-benefit analyses when developing regulations, and the IWG encourages the use of the SCC protocol in those cases. The Pawnee Oil and Gas Leasing Analysis was not prepared to support the promulgation of a regulation. Rather, the analysis was prepared to inform the Forest Service and BLM's decisions as to whether or not to make specific land available for oil and gas leasing, and the terms and conditions under which those lands may be leased.

Unlike EO 12866 (which is not applicable here), NEPA does not require a quantitative cost-benefit analysis. (40 CFR 1502.23). As contemplated in the CEQ regulations, the analysis recognizes that there are environmental costs associated with the development and use of fossil fuels. The analysis also identifies benefits of oil and gas development to the local economy and tax base, and to meeting the energy needs of the Country. The analysis appropriately weighs the merits and the drawbacks of the proposed action and alternatives, without reduction to a monetary or quantitative cost-benefit analysis that would likely be so imprecise as to be misleading.

The Pawnee Oil and Gas Leasing Analysis includes an economic impact analysis, to be distinguished from a cost-benefit analysis. A cost-benefit analysis examines the economic efficiency of a proposed action—the net change in social welfare resulting from the costs and benefits of a proposal, including consideration of market and non-market values. Presenting the SCC cost estimates quantitatively, without a complete monetary cost-benefit analysis which includes the social benefits of energy production, would be misleading.

Although an economic impact analysis was completed for this project, this is not the “benefit” side of a SCC cost-benefit analysis. The economic impact analysis estimates the distributional effects of an action on sectors of a regional economy, primarily by measuring the changes in employment and income within the geographic area where workers or businesses are most affected by the action. The economic impact analysis in the DEIS evaluated the economic impacts to the three-county area affected for different alternatives. However, this regional economic impact analysis in the DEIS was not a cost-benefit analysis, nor was it intended to quantify the social costs or benefits of fossil fuel development. .

The fact that the effects or costs of carbon emissions were not quantified does not mean that they were ignored. The DEIS evaluated the climate change impacts of the proposed action in qualitative terms. The Draft EIS quantified the estimated greenhouse gas emissions that would result from a high development scenario (p. 159-64). The total potential greenhouse gas emissions reported in the DEIS is conservatively high because “it is highly unlikely that all 354 wells could be drilled in the first year and continue to operate at maximum production capacity for 25 years” (p. 162). The DEIS puts these estimated emissions in context with state and national emissions levels. It qualitatively describes the potential increases in GHG emissions on the environment using climate projections specific to Colorado. This information is at a scale that is relevant and useful to the decision-maker and meets the requirements of NEPA.

The commenter cites EPA’s comments on the proposed Keystone XL oil pipeline EIS as an indication that the EPA has recommended use of the SCC protocol for project-level decisions. The EPA reviewed and commented on this draft EIS based on its authority under section 309 of the Clean Air Act. EPA’s comments did not include a recommendation to use the SCC protocol or any other estimate of the social cost of carbon or to prepare a quantitative cost-benefit analysis.

- (11) **Comment**-Some commenters requested that the ROD commit to future near field air quality analysis. Commenters requested this commitment be included as a Lease Notice as part of the Forest Service’s ROD.

Response-The applicability of Forest Service oil and gas leasing regulations relate only “...to leases on National Forest System lands and to operations that are conducted on Federal oil and gas leases on National Forest System lands as of April 20, 1990.”⁵⁶ A Lease Notice is a regulatory tool BLM possesses⁵⁷ “...to convey certain operational, procedural or administrative requirements relative to lease management within the terms and conditions of

⁵⁶ 36 CFR 228.100(b).

⁵⁷ A lease notice or informational notice is not mentioned in Forest Service oil and gas leasing regulations.

the standard lease form.”⁵⁸ As such, the Forest Service does not feel it is the appropriate Agency to include a lease notice in their ROD. This is especially true under the NSO Alternative because oil and gas development will not be allowed on the unleased portion of the PNG and the Forest Service does not review SUPOs on non-Forest Service lands.

Regardless of whether the Forest Service includes a lease notice regarding future near field air quality analysis, it is expected that this analysis (or an analysis of similar rigor and accuracy) will be completed before any oil and gas development is permitted. The Clean Air Act and NEPA require that federal permitting actions demonstrate compliance with federal, state, or local air quality standards in good faith and using generally accepted methods. For federal oil and gas development in Colorado, this normally includes near field air analysis. BLM includes a lease notice regarding air quality in all leases they issue in Colorado. This lease notice includes the following language regarding air quality analysis:

Due to potential air quality concerns, supplementary air quality analysis may be required for any proposed development of this lease. This may include preparing a comprehensive emissions inventory, performing air quality modeling, and initiating interagency consultation with affected land managers and air quality regulators to determine potential mitigation options for any predicted significant impacts from the proposed development. Potential mitigation may include limiting the time, place, and pace of any proposed development, as well as providing for the best air quality control technology and/or management practices necessary to achieve area-wide air resource protection objectives. Mitigation measures would be analyzed through the appropriate level of NEPA analysis to determine effectiveness, and will be required or implemented as a permit condition of approval (COA). At a minimum, all projects and permitted uses implemented under this lease will comply with all applicable National Ambient Air Quality Standards and ensure Air Quality Related Values are protected in nearby Class I or Sensitive Class II areas that are afforded additional air quality protection under the Clean Air Act (CAA).

Because BLM already includes a lease notice regarding air quality analysis, it is not necessary for the Forest Service to include this notice in the ROD.

- (12) **Comment-**Some commenters requested the FEIS include an appendix describing the air analysis and modeling methodology.

Response-The FEIS includes an appendix describing the air analysis and modeling methodology. See Appendix C.

⁵⁸ 43 CFR 3101.1-3

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- (13) **Comment-**Some commenters felt it was important that the EIS include an description of the modeling and analysis methodology to ensure that any changes to the BLM draft document do not impact or misrepresent the process used for the Pawnee air quality analysis.

Response: The current CARMMS is included in the FEIS as Appendix C.

- (14) **Comment-**Some commenters noted that the FEIS contains missing air analysis. This included National Ambient Air Quality Standards (NAAQS) for 1-hour and annual NO₂, 1-hour SO₂, and 1-hour and 8-hour CO; Prevention of Significant Deterioration (PSD) increments for 1-hour NO₂ and 1-hour SO₂; and cumulative impacts to 1-hour and annual NO₂. Commenters noted that the DEIS indicates that 1-hour NO₂ and 1-hour SO₂ impacts were not included due to the results being unavailable from the CARMMS platform at this time and that cumulative impact analyses were not included for NO₂ or CO. Given that an analysis for annual NO₂ was included for PSD increment comparison and the Draft EIS states that annual NO₂ concentrations may be over-estimated because of the model configuration, it seems that a cumulative analysis for annual NO₂ would have been processed and available.

Response-The CARMMS results for the requested pollutants and averaging periods were not available at the time the DEIS was prepared. As discussed in the DEIS on page 143, the 1-hour NO₂ and SO₂ standards are unlikely to be exceeded except in the vicinity of a source or group of sources, meaning, in the near-field. Near-field analysis is most useful when we have proposed locations and development plans identifying the types of equipment to be used. For any oil and gas development on the PNG, the BLM will conduct a near-field assessment of impacts to the 1-hour NO₂ and 1-hour SO₂ standards as discussed in the FEIS on page 139.

Since the DEIS was written additional CARMMS results have become available. These were received by the FS on October 27, 2014, and are included in the FEIS. These additional results will not take the place of future near-field analyses. These results will not include impacts to 1-hour NO₂ and 1-hour SO₂ PSD increments as there are presently no PSD increments for these averaging periods for these pollutants.

- (15) **Comment-**Some commenters felt the statement on pg. 157 of the DEIS was confusing on whether a leasing decision requires a conformity determination under the CAA.

Response-We agree with the commenter that the quoted sentence was poorly worded, as it implies that a conformity determination is required to accompany a leasing decision rather than as part of a subsequent federal action that would actually authorize development and associated emissions. This is corrected in the FEIS.

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- (16) **Comment-**Some commenters felt that a leasing decision requires a conformity determination under the CAA.

Response-Regarding the question about conducting conformity analysis for a programmatic decision where the Forest Service is determining which lands are potentially available for future leasing and under what conditions, we (FS, EPA, CO APCD, BLM, and other agencies) discussed extensively and repeatedly this question, as early as scoping and throughout the development of the EIS. As a result of these discussions the agencies concluded that conformity analysis is not needed at this time. Conformity analysis will be conducted during project-level analysis when there is a proposed action that will create emissions. The reason conformity analysis is not appropriate at this time can be summarized by two statements about this PNG decision: 1) This PNG decision authorizes no emission producing activities; 2) This PNG decision does not provide or confer lease rights, permission to drill, or approval for development. Additionally, because there are no actual proposals occurring at this stage, there is no way to know what type of equipment or associated control technology to analyze, or where it would be on the landscape relative to the non-attainment boundaries. It is our understanding that all agencies present during these discussions concurred with this approach to conformity determination and assessment.

The FS has reviewed and considered the referenced court order of January 17, 2012. This court order required BLM to prepare an emissions inventory for oil and gas operations within the Royal Gorge Field Office Planning Area, which includes the PNG. BLM has completed this inventory and used it to generate future projections that were incorporated into the CARMMS analysis. The order also required BLM perform an applicability analysis, and if necessary, a conformity determination, prior to reinstating four specific leases within the nonattainment area that had been terminated. The order does not suggest that a conformity determination must be completed before any other leases can be issued.

When the BLM leases parcels at auction for oil and gas development, this conveys a right to the lessee to develop the parcels but does not authorize any emissions. The BLM does not know in advance when offering parcels for lease who will be the successful bidders or even whether the parcels will be bid upon at all. Once a bid is accepted and a parcel is leased, the lessee has 10 years to begin development or the lease is automatically terminated. This area's non-attainment status can, and likely will, change over a ten-year period. Lessees typically do not present the BLM with a development plan at the time a lease is issued. Without such a plan, indicating how much development will occur and when and where it will occur, the BLM does not have specific information on emissions that it can use to conduct a conformity determination. Lessees are required to submit a detailed development plan when applying for a permit to drill. Lessees are not authorized to access federal minerals until the BLM approves the application for permit to drill (APD). The BLM has the authority to withhold

approval of the APD until the applicant can demonstrate that the project will comply with general conformity requirements. The BLM can also require mitigation measures, if needed, as part of the conditions of approval when issuing a permit. The BLM retains this authority over any development accessing federal minerals, regardless of whether the surface development occurs on federal or private surface.

BLM minerals specialists developed the reasonably foreseeable development (RFD) presented in this document by combining their own judgment with historical patterns of development in the area and with input from industry. This RFD represents the agency's best available estimate of the maximum amount of potential development that might occur within the period covered by this analysis. In order to use the RFD emissions estimates as inputs to the CARMMS modeling analysis, the BLM had to make its own assumptions as to how to distribute the emissions-producing activities across the landscape; it does not have any way to know how much of this estimated development might actually occur within the nonattainment area.

While the agency does its best to provide a reasonable estimate of potential development, this is nonetheless just the agency's best estimate and does not represent what will actually occur. The actual amount of development that will occur if leases are issued depends on many factors, including the extent and quality of the mineral resource, economic variables such as the future price and demand for those resources, and the future business decisions made by the lessees. The BLM cannot complete a conformity determination on the basis of its best estimate of maximum potential development, which is all that will be available at the time of leasing. This determination will occur during the project level NEPA analysis when APDs are considered.

- (17) **Comment-**Some commenters requested clarification related to the minor source permitting exemption. Specifically, the last sentence of the third full paragraph on p. 158 notes that "equipment and operations that undergo state air permitting (minor or major) would already be analyzed for their potential impacts to ozone pollution and a conformity analysis is not required as it would be redundant."

Response-The language in the referenced paragraph has been clarified in the FEIS.

- (18) **Comment-**Some Commenters advised that dispersion modeling is not an acceptable method for a general conformity determination for ozone since ozone is not a directly emitted criteria pollutant (see 40 CFR 93.258(a)(3)). They felt that emissions based conformity analysis for ozone precursor emissions of NO_x and VOCs (both direct and indirect emissions) is acceptable.

Response-The FS is aware that dispersion and photochemical modeling results are not acceptable for use in an ozone conformity analysis. The discussion beginning in the last two paragraphs of page 158 and continuing on to page 159 was intended to inform the reader that the BLM, as part of its ongoing planning efforts, is continuing to do further cumulative analysis of emissions from potential oil and gas development, and that these cumulative analysis results will be considered when determining whether to require mitigation for future development projects. The review described is separate from any federal conformity analysis that may be required. The review described would apply to any potential development on the PNG, not only those located within the nonattainment area. Should oil and gas development be proposed within the nonattainment area, the BLM will complete a conformity determination, if applicable, in accordance with the requirements of 40 CFR 93. Any conformity analysis that is performed will be emissions based as required by the general conformity regulations.

- (19) **Comment-**We also recommend describing potential measures to reduce GHG emissions associated with PNG oil and gas leasing. For example, potential measures for reducing the PNG's contribution to GHG emissions may include practicable mitigation to reduce GHG emissions including co-benefits achieved through implementation of air pollution controls for other air pollutants.

Response-This decision does not authorize any development activity or emissions. Should future development occur, the BLM will determine the level of mitigation, if any, needed to comply with ambient air quality standards. These mitigations may help to lower greenhouse gas emissions. BLM includes a lease notice regarding air quality that is included in all leases they issue in Colorado. This lease notice includes the following language regarding air quality analysis:

Due to potential air quality concerns, supplementary air quality analysis may be required for any proposed development of this lease. This may include preparing a comprehensive emissions inventory, performing air quality modeling, and initiating interagency consultation with affected land managers and air quality regulators to determine potential mitigation options for any predicted significant impacts from the proposed development. Potential mitigation may include limiting the time, place, and pace of any proposed development, as well as providing for the best air quality control technology and/or management practices necessary to achieve area-wide air resource protection objectives. Mitigation measures would be analyzed through the appropriate level of NEPA analysis to determine effectiveness, and will be required or

implemented as a permit condition of approval (COA). At a minimum, all projects and permitted uses implemented under this lease will comply with all applicable National Ambient Air Quality Standards and ensure Air Quality Related Values are protected in nearby Class I or Sensitive Class II areas that are afforded additional air quality protection under the Clean Air Act (CAA).

Potential emission reduction strategies that the BLM may identify for oil and gas development are listed in the Comprehensive Air Resource Protection Protocol (CARPP). The CARPP describes the process and strategies the BLM will use when authorizing activities that have the potential to adversely impact air quality within the state of Colorado.

- (20) **Comment-**Some commenters noted that the Draft EIS provides an explanation for why full lifecycle GHG emissions were not included in the emissions inventory and cites the difficulties at this planning stage in forecasting GHG emissions that would result from processing the extracted oil and gas into final products or from the end use of those products. However, they also noted that a representative analysis can be completed at the planning stage and has been done so in previous EISs (e.g. Dixie National Forest Oil and Gas Leasing Analysis EIS).

Response- The FS has reviewed and considered the air quality analysis that was conducted for the Dixie National Forest Oil and Gas Leasing Analysis EIS. As suggested, a similar analysis estimating end-use CO₂ emissions, based on a generic percentage breakdown of potential products, could be conducted for the PNG EIS; however, it is arguable how useful that analysis was for the Dixie EIS and similarly how useful such an analysis would be for this PNG programmatic EIS. It is unclear what value such an analysis adds to the EIS either for disclosure purposes or for the decision-maker's ability to choose between alternative – all of which have essentially identical potential future emissions. For this EIS, air quality is not one of the resource areas that changes by alternative.

The fact of midstream and end-use emissions of CO₂ from fossil fuel extraction, and subsequent conversion into fuels and other products, is not in doubt. Extracting fossil fuels, such as oil and gas, will lead to more CO₂ emissions at various stages in the life-cycle. Oil and gas extraction leads to CO₂ emissions. CO₂ is a greenhouse gas. The FS included discussions of GHGs and their impacts both in a general sense and specific to this decision in the EIS.

Relative emission factors per unit of some types of liquid fuel end-use products were reviewed and considered. However, quantifying the amount of CO₂ through midstream processing or by end product for this programmatic decision is potentially misleading due to

uncertainties in both quantity and quality of products (oil and gas) produced by any future development resulting from future leasing based on this decision's direction about which areas are available for leasing. Approving extraction of minerals is several decision steps further down the decision chain. Future demand for each potential end-use product is unknowable. Timing of extraction of the minerals is unknowable at this stage. Quantifying end-use CO₂ emissions by multiplying total estimated quantities of extracted minerals by generic percentage breakdowns of potential end products of a barrel of oil (or ccf of gas) is possible, but is highly speculative and rests on layers of assumptions – all of which must hold in order for the calculated numbers to be meaningful. Similar considerations apply to quantifying midstream emissions. Showing numbers is not always better analysis than refraining from showing numbers, especially when there is substantial uncertainty and little ability to bound that uncertainty. FS does not believe this to be a useful exercise for this PNG programmatic EIS, which is deciding what lands are available for potential leasing and under what stipulations. For all of these reasons, this kind of quantification was considered and dismissed as too speculative and was therefore not conducted.

The DEIS points out on page 162 that there is no accurate way to forecast the volume of oil and gas that may be extracted, and that the number of possible end products for these minerals is potentially very large. There is no way to forecast what those end products are likely to be, particularly over the length of time covered in this analysis (through 2021).

- (21) **Comment**-Some commenters felt it is important the FEIS note that the CARMMS and associated CARPP have not been fully vetted by the stakeholder agencies or the public.

Response The CARMMS modeling study is being vetted through an interagency workgroup in accordance with the *Memorandum of Understanding among the U.S. Department of Agriculture, U.S. Department of the Interior, and U.S. Environmental Protection Agency, Regarding Air Quality Analyses and Mitigation for Federal Oil and Gas Decisions Through the National Environmental Policy Act Process*. The FS hosted such two workgroup meetings where the air quality analysis and CARMMS results specific to the Pawnee were discussed, and the BLM has hosted additional meetings to discuss the CARMMS modeling study and present the first set of results for the high development scenario. BLM will host additional meetings to present further results that will include low and medium development scenarios. When the CARMMS study is complete, the results will be available to the public through the BLM's web site. In addition, CARMMS results (especially for cumulative impacts) will be disclosed for other Colorado –based EIS' in the near future (including the Grand Junction Field Office and Uncompahgre Field Office Resource Management Plan EIS') for future public and stakeholder review. The CARMMS protocol, which describes how the study is being conducted, is included in the project record. The CARMMS was built upon the WESTJUMP study platform, which is a similar regional air quality study that

underwent a thorough interagency review process. The CARMMS analysis is the best available information on air quality impacts that might result from future oil and gas development on the PNG at this time.

The CARPP describes the process and strategies the BLM will use when authorizing activities that have the potential to adversely impact air quality within Colorado. This document is a planning tool that describes options that BLM may employ when authorizing specific projects, but is not a NEPA document itself. The CARPP has nonetheless undergone an extensive interagency review process during which comments were received from many agencies, including the FS, National Park Service, and EPA. The CARPP is publicly available now as part of Grand Junction Resource Management Plan, among others.

- (22) **Comment**-Some commenters felt that the air modeling results for the PNG did not consider the impacts of existing federal wells in conjunction with anticipated new wells... The document should disclose future emissions associated with existing and new active wells in PNG planning area.

Response-The DEIS presented results from the CARMMS study for new wells that could potentially be drilled during the study period within the boundaries of the Pawnee National Grassland. This is appropriate for this analysis, as existing wells will remain regardless of the decision that is made. The DEIS also included cumulative analysis results showing projected impacts to air quality that could result from all sources of air pollutants within the study area, including existing wells on the PNG.

The DEIS does not include an analysis of impacts from all federal wells within the region as this would be beyond the scope of the decision under consideration. It is also beyond the scope of this analysis to explain how cumulative air quality impacts from oil and gas development will be addressed on a region-wide basis. The FS does not have authority to address air quality impacts from development that may occur beyond the PNG boundaries. However, CARMMS will include additional results for federal oil and gas development that may occur beyond the boundaries of the PNG, and these results will be made available by the BLM when completed.

- (23) **Comment**-Some commenters felt the DEIS does not adequately analyze and assess air quality impacts, including impacts to National Ambient Air Quality Standards (“NAAQS”) for ozone, nitrogen dioxide (“NO₂”), and particulate matter, including both PM₁₀ and PM_{2.5}.

Response-The decision under consideration will not authorize any development or emissions either on or off Pawnee NG surface. The statement that “...emissions estimates are based solely on air quality impacts that would occur on the Pawnee National Grassland...” is not correct. As discussed in the DEIS on page 136 (under the heading ‘Analysis Area’), the air

quality analysis considered potential impacts of up to 354 wells that might be drilled within the outer boundaries of the PNG. Under Alternatives 2 and 3, this includes up to 265 wells accessing federal minerals underneath PNG surface and an additional 89 wells accessing federal minerals under private surface. As stated in the DEIS, “For air quality, the potential effects of all wells that would access Federal minerals and associated development within the PNG boundary were considered.” The DEIS also clearly states that the air quality analysis considered the impacts of these potential 354 wells for both alternatives 2 and 3, which includes the alternative under which the FS would make lands available for leasing under no surface occupancy. In addition, because development would likely occur under Alternative 1 (no leasing), the air analysis considered the impacts to air quality that would occur from 354 potential wells for all alternatives. This analysis did not distinguish between alternatives that would permit surface occupancy and those that would not, as the emissions would still occur. This is clearly stated in the DEIS.

Modeled impacts from potential future oil and gas development to ozone concentrations are disclosed in the DEIS on page 144. Modeled impacts to cumulative ozone concentrations are disclosed in the DEIS on pp. 148-149.

- (24) **Comment-**Some commenters felt the DEIS did not include an emissions inventory

Response-BLM minerals specialists developed the reasonably foreseeable development (RFD) presented in this document by combining their own judgment with historical patterns of development in the area and input from industry. This RFD represents the agency’s best available estimate of the maximum amount of potential development that might occur within the period covered by this analysis. In order to use the RFD emissions estimates as inputs to the CARMMS modeling analysis, the BLM had to make its own assumptions as to how to distribute the emissions-producing activities across the landscape; it does not have any way to know how much of this estimated development might actually occur within the nonattainment area. The DEIS did not estimate the quantity of the estimated emissions that might occur within the nonattainment area. It is extremely unlikely, however, that all development would occur within the nonattainment area, as only part of the PNG lies within it. Therefore, as the emissions inventory presented is only an estimate with no information about spatial distribution, there is no “known” inventory to use for an ozone conformity analysis. Furthermore, no ozone conformity analysis is required for this decision as it will not authorize any emissions generating activities.

- (25) **Comment-**Some commenters felt that the DEIS does not analyze or assess the impacts of reasonably foreseeable development to NAAQS that limit NO₂ concentrations on an hourly basis. The DEIS acknowledges that no such analysis has been done, but asserts with no supporting information or analysis that impacts cannot be determined due to a lack of site-specific proposals.

Response-The CARMMS results for the requested pollutants and averaging periods were not available at the time the DEIS was prepared. As discussed in the DEIS on page 143, the 1-hour NO₂ and SO₂ standards are unlikely to be exceeded except in the vicinity of a source or group of sources, meaning, in the near-field. Near-field analysis is most useful when we have proposed locations and development plans identifying the types of equipment to be used. For any oil and gas development on the PNG, the BLM will conduct a near-field assessment of impacts to the 1-hour NO₂ and 1-hour SO₂ standards as discussed in the FEIS on page 154-155.

Since the DEIS was written additional CARMMS results have become available. These were received by the FS on October 27, 2014, and will be included in the FEIS. These additional results will not take the place of future near-field analyses. These results will not include impacts to 1-hour NO₂ and 1-hour SO₂ PSD increments as there are presently no PSD increments for these averaging periods for these pollutants.

- (26) **Comment-**Some commenters noted that the DEIS presents no analysis or assessment of impacts to NAAQS for both particulate matter less than 10 microns in diameter and particulate matter less than 2.5 microns in diameter. It does not appear that any reasonable analysis of particulate matter air quality impacts is included in the DEIS.

Response: Potential future development-related particulate matter emissions (PM₁₀ and PM_{2.5}) are disclosed in the DEIS in Table 43 on page 140. Modeled impacts from these emissions to particulate matter concentrations are disclosed in Table 44 on the bottom of page 142 and in the first paragraph on the top of page 143. Modeled cumulative impacts to particulate matter concentrations are disclosed in the DEIS on pages 152-155.

- (27) **Comment-**The LRMP for the Arapaho and Roosevelt National Forests and Pawnee National Grassland requires that all land management activities be conducted in such a manner “as to comply with all applicable federal, state, and local air-quality standards and regulations.” Standard 2, LRMP at 13. Here, given the DEIS’s failure to adequately analyze and assess impacts to NAAQS for ozone, NO₂, and particulate matter, the USFS cannot demonstrate that this standard will be met pursuant to NFMA.

Response-No emissions will be authorized as a result of this decision and therefore there will be no direct impacts to air quality standards. However, the DEIS assesses indirect impacts from potential future emissions that might result if parcels are leased and oil and gas development is authorized. Impacts to NAAQS standards for ozone and particulate matter are disclosed on pages 148-149 and 153-155. Additional information on impacts to NO₂ standards that was not available at the time the DEIS was written will be added to the FEIS.

The air quality modeling results presented in the DEIS represent potential impacts that may occur if parcels are leased and oil and gas development occurs. Additional NEPA analysis will be conducted by the BLM at the project level that will include a near-field analysis. The decision being considered here will therefore be in compliance with the NFMA and the PNG LRMP.

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- (28) **Comment**-Some commenters felt the DEIS does not analyze the greenhouse gases or other air pollutants that surely result from this reasonably foreseeable impact.

Response-The FS decision not to include the analysis described by the commenter is not arbitrary and capricious; it is an intentional choice made after considering relevant information, and after thoroughly debating the merits of including such an analysis.

The DEIS points out on page 162 that there is no accurate way to forecast the volume of oil and gas that may be extracted, and that the number of possible end products for these minerals is potentially very large. There is no way to forecast what those end products are likely to be, particularly over the length of time covered in this analysis (through 2021). Any attempt to determine greenhouse gas emissions or other pollutants resulting from the use of oil and gas from the PNG would require the FS to make many assumptions about how these minerals would be used and where they would go. There would be no way to have any confidence in those assumptions or to make any estimates of the error surrounding the resulting greenhouse gas emissions figures. Such an analysis would not be useful or provide the decision maker with any additional information that could be used to discriminate among alternatives.

The EPA has suggested completing an analysis similar to one that was done by the Dixie National Forest. The FS has reviewed and considered the air quality analysis that was conducted for the Dixie National Forest Oil and Gas Leasing Analysis EIS. As EPA suggests, a similar analysis estimating end-use CO₂ emissions, based on a generic percentage breakdown of potential products, could be conducted for the PNG EIS; however, it is arguable how useful that analysis was for the Dixie EIS and similarly how useful such an analysis would be for this PNG programmatic EIS. It is unclear what value such an analysis adds to the EIS either for disclosure purposes or for the decision-maker's ability to choose between alternatives – all of which have essentially identical potential future emissions. For this EIS, air quality is not one of the resource areas that changes by alternative. The fact of midstream and end-use emissions of CO₂ from fossil fuel extraction, and subsequent conversion into fuels and other products, is not in doubt. Extracting fossil fuels, such as oil and gas, will lead to more CO₂ emissions at various stages in the life-cycle. Oil and gas extraction leads to CO₂ emissions. CO₂ is a greenhouse gas. The FS included discussions of GHGs and their impacts both in a general sense and specific to this decision in the EIS.

Relative emission factors per unit of some types of liquid fuel end-use products were reviewed and considered. However, quantifying the amount of CO₂ through midstream processing or by end product for this programmatic decision is potentially misleading due to uncertainties in both quantity and quality of products (oil and gas) produced by any future development resulting from future leasing based on this decision's direction about which areas are available for leasing. Approving extraction of minerals is several decision steps further down the decision chain. Future demand for each potential end-use product is unknowable. Timing of extraction of the minerals is unknowable at this stage. Quantifying end-use CO₂ emissions by multiplying total estimated quantities of extracted minerals by generic percentage breakdowns of potential end products of a barrel of oil (or ccf of gas) is possible, but is highly speculative and rests on layers of assumptions – all of which must hold

in order for the calculated numbers to be meaningful. Similar considerations apply to quantifying midstream emissions. Showing numbers is not always better analysis than refraining from showing numbers, especially when there is substantial uncertainty and little ability to bound that uncertainty. FS does not believe this to be a useful exercise for this PNG programmatic EIS, which is deciding what lands are available for potential leasing and under what conditions. For all of these reasons, this kind of quantification was considered and dismissed as too speculative and was therefore not conducted.

- (29) **Comment-**Some commenters felt the FEIS should include an estimate of methane leakage from projected wells.

Response-Methane leaks were accounted for in the estimated emissions presented in the DEIS. Table 52 on page 162 includes an estimate of the annual emissions of methane that might result from future oil and gas development on the PNG. To estimate this value, the BLM used EPA-approved emissions factors for the types of equipment included in the emissions inventory and determined the amount of methane emissions on a per-well basis (based on the amount of equipment typically associated with each well). This number was multiplied by 354 to give an estimate of maximum possible emissions that might occur under the assumption that all 354 wells might be producing in a single year. Of this total (6,068 tons), approximately 75% results from wellhead and compressor equipment leaks (including pneumatic devices), and most of the remaining methane emissions come from blowdown venting. This method of calculating methane leaks varies with the numbers and types of equipment and is independent of production. The FS believes that using accepted EPA emissions factors is the appropriate method for estimating methane leaks and represents the best available information. The EPA protocol for estimating emission leaks can be found online at <http://www.epa.gov/ttnchie1/efdocs/equiplks.pdf>.

The FS is aware of the research being done by NOAA and other agencies to better characterize methane leakage rates from oil and gas production fields. The FS consults with NOAA and other researchers on this matter. The FS has reviewed and considered the referenced Nature article from 2012. This article is a news summary article about methane leakages and provides an overview of NOAA's preliminary findings. The article is not a peer-reviewed research paper written by the investigators themselves. It represents one method of estimating leakage rates by sampling atmospheric methane concentrations in the vicinity of oil and gas producing fields. The 4% leakage rate mentioned in the article is not settled science; the article itself mentions that there has been a range of values reported and that some studies suggest lower values. NOAA's work in this area is ongoing. NOAA was a participant agency this past summer in the multi-agency Front Range Air Pollution and Photochemistry Experiment (FRAPPE) that was conducted along the Colorado Front Range (<https://www2.acd.ucar.edu/frappe>). Results from this study are forthcoming.

It is not known what the volume of natural gas from a typical well would be if development occurs on the PNG. However, the BLM has examined historical production rate information for gas-producing wells in the area of the PNG and estimated that average per-well production has been approximately 31 million ft³ per year for the first few years after a well is drilled, when it is most productive (personal communication with Forrest Cook, BLM,

October 28, 2014). Using this figure and multiplying by 14,000 pounds of methane per million cubic feet of gas and 354 wells, the result is an estimated 76,818 tons of methane production per year if all 354 wells are operating. The DEIS disclosed estimated methane emissions of 6,068 tons per year. This yields a loss rate of methane to the atmosphere of $6,068/76,818=0.079$, or just under 8% of the estimated production. Therefore, even if the preliminary estimate of 4% quoted in the article is ultimately determined to be the best scientific estimate for methane loss rates for oil and gas production in the area of the PNG, the methane emissions presented in the DEIS represent a rate almost twice as high. It is thus a reasonable, conservative estimate of the rate of potential methane loss to the atmosphere and within the range of values reported in the Nature article.

(30) **Comment-**One commenter stated that:

The DEIS reports that the global warming potential for methane is 21 times greater than carbon dioxide over 100 years. DEIS at 135. This characterization is outdated, however. Although the EPA has identified that methane has a global warming potential that is 25 times greater than carbon dioxide over a 100 year period (i.e. is 25 times more potent as a greenhouse gas) (see 78 Fed. Reg. 71904, 71909 (Nov. 29, 2013)), the Intergovernmental Panel on Climate Change (“IPCC”) has assigned methane a global warming potential of 34 over a 100-year period and 86 over a 20-year period. See IPCC, Climate Change 2013: the Science Basis. Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press (2013) at 731, available at <http://climatechange2013.org/>. To ignore the more recent values for methane global warming potential is arbitrary and capricious. To ignore the 20-year value is also arbitrary and capricious. Both of those values must be considered.

Response-The quoted figure from the DEIS (a global warming potential of 21 times that of CO₂ over 100 years) was taken from the Environmental Protection Agency’s (EPA) web site on greenhouse gases (<http://epa.gov/climatechange/ghgemissions/gases/ch4.html>). According to the website, it was last updated on July 2, 2014, and therefore appears to be current. The FS is aware that there are various ways to compare the global warming potential of different greenhouse gases on an equivalent basis. The FS chose to use the figure given by EPA because it is a federal government agency with considerable expertise on greenhouse gases.

The FS has reviewed and considered the information on global warming potential (GWP) contained in the IPCC 2013 report. Table 8.A.1 on page 731 lists the 100-year GWP of methane as 28 and the 100-year GWP of fossil methane as 30. Estimating the GWP of a greenhouse gas is a complex process that takes into account a number of different factors; the document itself points out that “...there is no universally accepted methodology for combining all the relevant factors into a single global warming potential for greenhouse gas emissions.” (p. 710). According to the report, the choice of time horizon is a value judgment that has a strong effect on the GWP values (p. 711). In addition, even for a particular time horizon there is considerable uncertainty surrounding the GWP. The IPCC 2013 report says that the uncertainty in GWPs for gases with lifetimes of a few decades is estimated to be of the order of $\pm 25\%$ and $\pm 35\%$ for 20 and 100 years; the uncertainties in GWPs will be larger

for shorter-lived gases. The IPCC assesses the uncertainty to be of the order of $\pm 75\%$ for the 100-year GWP of methane (p. 713). The lifetime of methane is given as 12.4 years (p.731).

Given the uncertainties surrounding the GWP estimates and the judgment involved in choosing an appropriate time horizon to use, the FS believes the use of the EPA's widely used and accepted estimates of this metric to be a reasonable choice and sufficient for the decision that is being made. Additional GHG equivalent estimates for methane using the GWP value of 25 published by EPA in the Federal Register will be added to the FEIS.

Other Resource and Analysis Comments

- (31) **Comment**-Some commenters felt that consultation under Section 7 of the Endangered Species Act (ESA) must be completed before a leasing decision is made.

Response-There are no threatened or endangered species on the PNG. However, the FEIS recognizes that there are threatened and endangered species that could be impacted by water depletions in the South Platte Basin (see FEIS pp. 111 and 122-123). These species include; whooping crane, piping plover, least tern, and pallid sturgeon. The U.S. Fish and Wildlife Service developed the Platte River Recovery Implementation Program to address these water depletion impacts.⁵⁹ The purpose of this program is to provide ESA compliance for water users in the Platte River basin upstream of the Loup River confluence. The program establishes consultation procedures for any water depletions in the South Platte Basin above de minimis thresholds. Because a leasing analysis and decision does not result in any water depletion, consultation under the program is not timely.

However, it is expected that consultation under this program may occur during review of any APD—when water sources and quantity are known. If water depletions exceeding de minimis thresholds are proposed in the South Platte Basin, it is expected that consultation under the Platte River Recovery Implementation Program will be completed before any APD is approved.

- (32) **Comment**-Some commenters felt that the NSO Alternative does not meet Forest Plan standards for watershed protection, wildlife viability, or air quality.

Response-The NSO Alternative will not result in any ground disturbance, wells, or well pads being located on the PNG. Most of the watershed related standards in the Forest Plan relate to how surface disturbing activities should be conducted on National Forest System Lands. Because the NSO Alternative will prohibit surface disturbance, it meets these standards.

⁵⁹ An overview of the Platte River Recovery Implementation Program is available at: <http://www.fws.gov/platteriver/>

The wildlife analysis concludes that the NSO Alternative will not imperil wildlife viability (see FEIS pp.113-114 and 130-131). Similar to watersheds, this is primarily because surface disturbance will not be allowed on the unleased federal mineral estate. Although oil and gas development may occur on non-National Forest Service lands, it is not without consideration of wildlife impacts. For example, COGCC rules and regulations specifically identify wildlife considerations before approving oil and gas development and BLM routinely includes wildlife based conditions of approval for any APD.

A leasing analysis and decision does not result in any emissions. Therefore, it complies with all applicable federal, state, and local air quality standards. However, the FEIS also recognizes that before an APD can be approved it must be demonstrated that the permit will not cause any exceedance of federal, state, or local air quality standards (see FEIS pp. 195-196). Because actual emissions or the location of those emissions are not known at the leasing analysis stage, this FEIS does not attempt to satisfy those determinations.

- (33) **Comment-**Some commenters noted that a statement regarding environmental justice on pg. 260 of the DEIS is incomplete.

Response-This section on environmental justice has been revised. See FEIS pp. 285-286.

- (34) **Comment-**One commenter noted that the economics section of the DEIS is confusing and appears to rely on an “outdated” RFD.

Response-This sentence has been reworded to clarify that the economics analysis relies on the RFD prepared by BLM in March 2012 (see Appendix A).

- (35) **Comment-**Some commenters requested the FEIS identify incomplete or unavailable information.

Response-The FEIS discloses that a leasing analysis relies on incomplete and unavailable information (see FEIS pg. 9-10 and 48-49, 97 and 247) to evaluate post leasing activities. Missing information includes (1) where oil and gas development will be proposed; (2) when it will occur; (3) what surface use will be proposed; and (4) what conditions of approval may be required in any approved APD. In addition, the FEIS also acknowledges the lack of conclusive or definitive studies on the risks of oil and gas development (see FEIS pg. 49). Many of these studies span multiple years and involve extensive effort.⁶⁰ Conducting these studies for this EIS is beyond the scope of this analysis effort.

⁶⁰ For example, EPA began a study in March 2010 to better understand any potential impacts of hydraulic fracturing for oil and gas on drinking water sources. Results of this study will not be available until early 2015.

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- (36) **Comment-**Some commenters requested the Forest Service disclose possible environmental impacts to the Western Prairie Fringed Orchid and Colorado Butterfly Plant.

Response-A pre-field review was conducted for all rare plant species potentially occurring in, or known to occur nearby, the proposed project area. The review effort focused on proposed, threatened, and endangered plant species known or believed to occur in or near the planning area; including the Western Prairie Fringed Orchid and Colorado Butterfly Plant. The United States Fish and Wildlife Service (USFWS) Information, Planning, and Conservation System (<http://ecos.fws.gov/ipac/>) reports that there are two federally listed plant species that are known or are believed to occur in the planning area. Two threatened plant species are listed in the system for the ARP that may occur on the PNG: Ute ladies'-tresses orchid (*Spiranthes diluvialis*) and Colorado butterfly plant (*Gaura neomexicana* ssp. *coloradensis*) are known to occur in Weld County, Colorado. Furthermore, the Threatened plant Western prairie fringed orchid (*Platanthera praeclara*) is known to occur on the main stem of the Platte in Nebraska.

Extensive field surveys have been conducted in numerous past years by Forest Service staff and others familiar with the plants and habitat requirements of these two species, and no plants have been found during these surveys, including repeated visits to the best-quality habitats over multiple years (Popovich pers. comm. with Randall Reichert, 2014). Consequently, confidence is high in leading to a determination of presumed absence. Habitats for these species depend primarily on wetland and/or sub-irrigated fields adjacent to perennial waters that remain moist through most of the growing season. Although the project area is interspersed with several intermittent stream-course potholes, there are very few perennial or near-perennial streams that have the underflow, recharge, and/or discharge properties necessary to maintain adequate moisture in the unsaturated zone of the soil to support these threatened species. In addition, recent and sustained drought periods have further altered stream hydrology processes needed to maintain suitable habitat, and over time may have reduced the likelihood of presence of surviving plants for both species. At best, habitat in certain areas can be considered marginal.

- (37) **Comment-**Some commenters felt that the EIS incorrectly characterizes culverts as barriers to fish movement.

Response-It has been well recognized by fisheries managers, roadway engineers, and environmental planners that road culverts fragment aquatic habitat (e.g., Gucinski et al. 2001, Clarkin et al. 2005). Within small streams, the daily and seasonal movements of cyprinid (minnows) and fundulid (topminnows) fishes through road culverts are significantly impeded when compared to natural streambed conditions (Warren and Pardew 1998). Further, culverts and other structures that fragment habitat on prairie streams are listed as

conservation threats for both plains topminnow (Rahel and Thel 2004a) and plains killifish (Rahel and Thel 2004b).

Secondly, the fact that dispersal opportunities for PNG fish species only occur under certain environmental conditions and that PNG fish species must colonize newly available habitats when opportunities exist only exacerbates the environmental impact a road culvert may have on both upstream fish dispersal and species persistence in a fragmented stream habitat network.

- (38) **Comment-**Some commenters felt there is a contradiction regarding the relationship between the persistence of sedimentation and the likelihood of large precipitation events (DEIS pg. 75). They felt that the characterization of sediments persisting in streams for up to 10 years because of the lack of large precipitation events was inconsistent with the EIS's statement that flood events are infrequent (e.g. once every year or two).

Response-The description of "flood events" provided on page 75 describes the range precipitation events that supply the water that sustains the PNG aquatic habitats. It was meant as an "although" statement.... "[Although]...flood events are...infrequent and...short duration [presumed low magnitude], [other] events can be very high in magnitude". The commenters characterization that "extreme flood events occur every year or two" represents an incorrect interpretation of the DEIS. 100-year and 500-year flood events occur on average every 100 or 500 years, respectively.

If you apply these different types of "flood" events to sediment transport capacity within the prairie stream network, then it becomes more clear how sediment deposition is likely to persist in suitable habitats for long-periods of time (>10 yrs). Low magnitude events (every 1 to 2 years) are small wetting events that link aquatic habitats and do not have sufficient stream power to scour and redistribute sediments. On the contrary, the high magnitude intense flood events (>100 yr streamflow) may have sufficient stream power to scour and redistribute sediments within the small spatial extents where they occur. However, given the infrequency (>10 year returns at best) and small spatial extent of the extreme flood (>100-yr streamflow) events, it is indeed very unlikely that scouring of deposited sediments would occur broadly enough and with sufficient recurrence to actually remedy the deleterious effects of sediment deposition into the limited patches of suitable habitat on the PNG.

- (39) **Comment-**Some commenters felt that the DEIS should include a discussion of the Migratory Bird Treaty Act (MBTA) and Bald and Golden Eagle Protection Act (BGEPA).

Response-Under the MBTA, it is illegal to pursue, hunt, take, capture, kill, possess, sell, barter, purchase, export, or import migratory birds, their parts, nests or eggs, except as

permitted by regulation. “Take” is defined under the MBTA as “pursue, hunt, shoot, wound, kill, trap, capture, possess, or collect”. The MBTA does not require intent to be proven, and unless permitted by the USFWS, the MBTA prohibits any intentional or unintentional activity that results in the take of migratory birds.

The BGEPA prohibits the take, possession, sale, purchase, barter, offer to sell, purchase, or barter, transport, export or import, of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit (16U.S.C 668(a); 50 CFR 22). “Take” is defined as “pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb” a bald or golden eagle. The term “disturb” under the BGEPA was recently defined via a final rule published in the Federal Register on June 5, 2007 (72 Fed. Reg. 31332). “Disturb” means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.

Because an oil and gas leasing decision does not authorize any oil and gas development, this decision is consistent with the MBTA and BGEPA. If an APD is approved, it is the responsibility of the operator to ensure their actions do not cause violations of the MBTA or BGEPA

- (40) **Comment-**Some commenters felt that the economic analysis is flawed because it relies on a different success rate than the RFD.

Response-The economic analysis is based on a 95% drilling success rate, with horizontal drilling forecasted to have a near 100% success rate. Although this success rate is higher than the 87% success rate reported in the RFD, the Niobrara is an extension of the Greater Wattenberg field and is known to have continuous reserves. The RFDS estimates the Royal Gorge has an average drilling success rate at 87% (pg 14). This average is based the success of existing vertical, horizontal, and rank exploratory wells typically called “wildcats.” The RFDS estimates that development wells will have a success rate of about 93% (pg 14) and that the Greater Wattenberg AQNAAs will have an average success rate of 90% (pg 31). The RFDS suggests that horizontal drilling in the Niobrara will extend to the north of the Greater Wattenberg AQNAA (pg 19) and master development plans indicate that the large majority of new wells will be horizontal development wells. Recent horizontal drilling on private minerals surrounding federal minerals has proven to be very successful, with rates much higher than those observed for vertical and wildcat wells in the Royal Gorge. The RFDS assumes that at least one well per pad will be productive and that no pads will be abandoned. Therefore, relative to pad drilling there will be no abandoned pads because all pads can be expected to have at least one productive well. We anticipate that each pad will have multiple productive wells given recent history in Niobrara Formation drilling. As a

consequence we believe that, as stated in the RFDS all pads will have productive wells, the success of pads will approach 100%.

- (41) **Comment-**Some commenters felt the 8% to 10% unemployment rate used in the economic analysis section was incorrect.

Response-The Economic section of the Affected Environment discusses trends in the annual unemployment rates for the US, Colorado, and the three counties of interest as reported by the Bureau of Labor Statistics. These statistics are not seasonally adjusted and not comparable to Current Employment Statistics -CES (National) statistics.

In series ID: LNU04000000, BLS reports that the national unemployment rate exceeded 8% between 2009 and 2012, and fell to 7.4% percent in 2013. Since 2014 has not ended, compared national statistics for 2014 are not yet available.

- (42) **Comment-**Some commenters felt the economic benefits of oil and gas development were overstated.

Response-The discussion of anticipated development in Chapter 3.10.2 Environmental Consequences of Fluid Mineral is being revised to include a discussion of why federal mineral production is anticipated to increase under all alternatives. Since federal mineral leases are subject to valid and existing rights, the terms and stipulations of existing leases would not be affected by management actions discussed in the DEIS. While no new leases would be issued under the Alternative 1, existing leases ($\approx 40,000$ acres) are anticipated to experience greater development over the next 20 years. New wells are anticipated to be drilled on existing leases, and these wells are anticipated to have a very high success rate. Since federal leases do not expire once they are considered held by production, none of the existing leases are anticipated to expire over the next 20 years.

As for the economic impacts of future development, three direct effects were modeled a) an increase in drilling activity, b) and increase in output by the oil and gas industry, and c) increase in local revenues collected through rents, royalties, bonus bids, and excise taxes. Direct economic impacts associated with drilling and local revenues were modeled as a change in industry activity and government spending. Direct impacts associated with increased oil and gas production were estimated based on an employment to industry output ratio and modeled as a change in employment in IMPLAN rather than a standard change in final demand in order to account for high price volatility. These impacts were modeled based on assumptions of production and development discussed in Environmental Consequences of Fluid Minerals section, recent bonus bids, current rental rates, and effective tax rates.

The DEIS is intended to disclose potential impacts of reasonably foreseeable oil and gas development. It is important to highlight that impacts are not synonymous with benefits. Economic impacts reflect a net change in economic activity, while benefits reflect a net change in social welfare – see Watson et. al, 2007 for a detailed explanation of the differences between economic impacts and benefits. While the DEIS does not include an efficiency analysis to examine how social welfare may be affected by future leasing and

development on the Pawnee, it does include an economic activity analysis which examines how the flow of money to local households and businesses may be affected. The results of this type of analysis are generally reported in terms of the change in business sales, jobs, value added, income, or tax revenue. While jobs, income, and revenue are often mistaken for benefits, even though they are considered costs to production in benefit-cost analysis.

- (43) **Comment-**One commenter requested the FEIS include additional water analysis including:
- a. Identifying ground and surface water sources of public drinking water supplies and the associated source water assessments and source water protection zones
 - b. Including a map of private water wells in the area.
 - c. Including a discussion of the COGCC's requirements for groundwater monitoring (including Rule 609, Statewide Groundwater Baseline Sampling and Monitoring, and Rule 318A, Greater Wattenberg Area Special Well Location, Spacing, and Unit Designation) and noting areas of the PNG that would be subject to these requirements.

Response-These items have been added to the FEIS discussion of water resources on pp. 64-66.

- (44) **Comment-**One commenter felt that the DEIS underestimates water quantity impacts

Response-The FEIS clarifies how water quantity was determined on pg. 77.

Chapter 5-List of Preparers and Persons, Agencies, and Organizations Who Received a Copy of the FEIS

5.1 List of Preparers:

Preparers include members of the Arapaho and Roosevelt National Forests and Pawnee National Grassland. The following table lists interdisciplinary team (IDT) of resource specialists and their contribution:

IDT Member	Contribution
Joshua Milligan	Team Leader
Jim Burd	Fluid Minerals
Kristen Philbrook	Wildlife Resources
Larry Fullenkamp	Heritage Resources
Amy Coe	Geographical Information Systems
Matt Fairchild	Fisheries Resources
Deb Miller/ Eric Schroeder	Air Resources
Deb Entwistle	Water Resources
Lizandra Nieves	Soil Resources
Jennifer Dobb	Economics
Chelsea Gunsalus	Writer/Editor
Randall Reichert	Grazing/Noxious Weeds/Botany
Jared Smith	Scenic Resources
Michelle White	Transportation
Bruce Schumacher	Palentology

5.2 Distribution of FEIS

The following agencies received a copy of the FEIS:

Environmental Protection Agency

National Agricultural Library

Eighty-one other agencies, organizations and private individuals received notification that the FEIS was available on the Forest Service World-Wide Web.

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